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Variable ratio multi-gear

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ABSTRACT

A gear ratio set including a centre shaft, cage and outer body. A first member is between the centre shaft and the cage for communicating movement therebetween, and a second member is between the cage and the outer body for communicating movement therebetween. Upon rotation of one said component (shaft, cage or outer housing) at least one of the remaining components is caused to rotate. The output from one component (shaft, cage, or outer housing) is such that variation of a load between zero and a maximum value corresponds to variation of the ratio of the angular velocity between the other two or more components. This variation is achieved by a second input or braking effect.

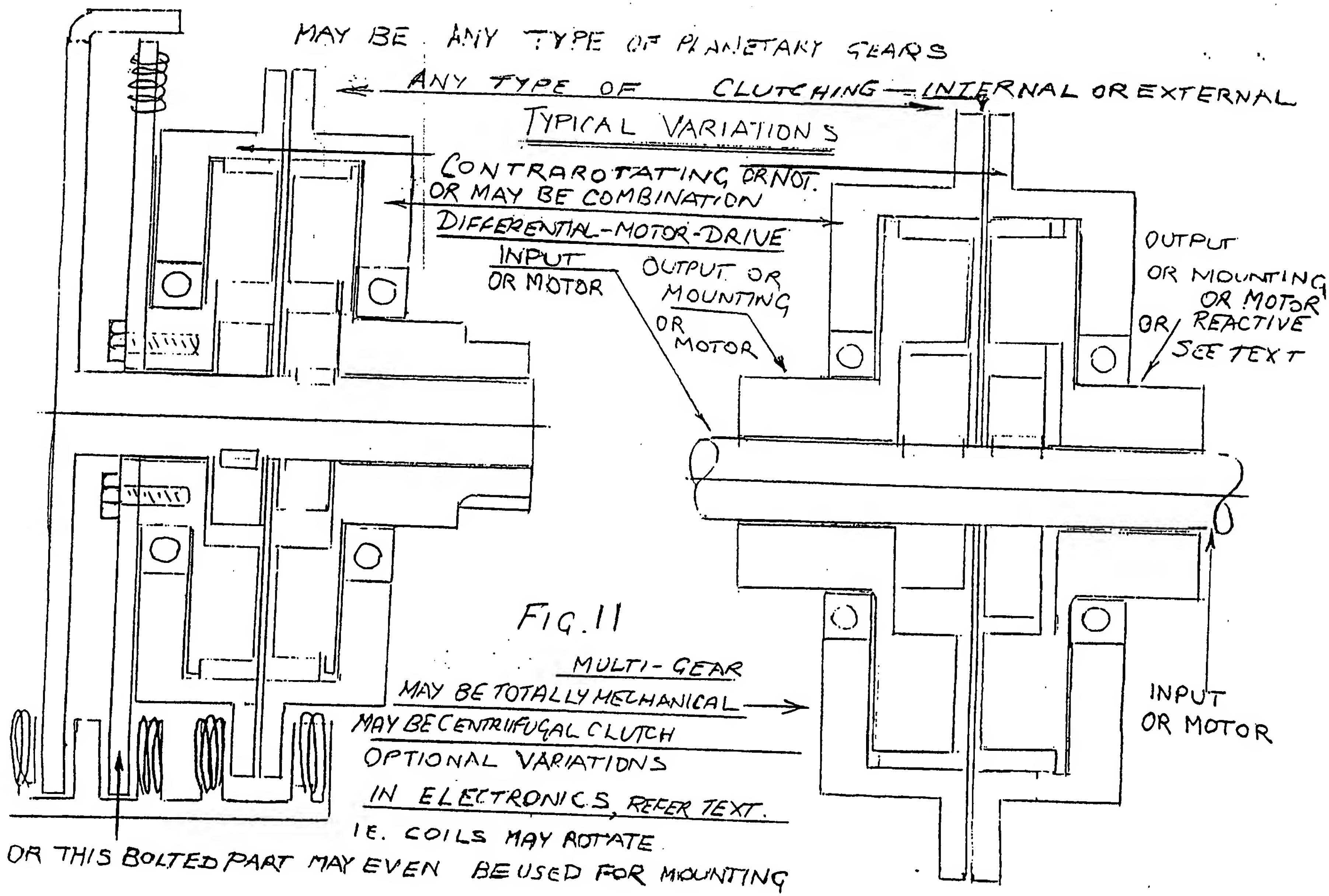

MAY BE ANY TYPE OF PLANETARY GEARS
ANY TYPE OF CLUTCHING — INTERNAL OR EXTERNAL
TYPICAL VARIATIONS
CONTRAROTATING OR NOT.
OR MAY BE COMBINATION
DIFFERENTIAL-MOTOR-DRIVE
INPUT
OR MOTOR
OUTPUT OR
MOUNTING
OR
MOTOR
OUTPUT
OR MOUNTING
OR MOTOR
OR/ REACTIVE
SEE TEXT
MULTI-GEAR
MAY BE TOTALLY MECHANICAL
MAY BE CENTRIFUGAL CLUTCH
OPTIONAL VARIATIONS
IN ELECTRONICS, REFER TEXT.
IE. COILS MAY ROTATE
INPUT
OR MOTOR
OR THIS BOLTED PART MAY EVEN BE USED FOR MOUNTING

FIG. 11

TITLE: VARIABLE RATIO MULTI-GEAR

This invention relates to devices for the transmission of mechanical power in the form of rotational motion. In particular, it is directed to transmission of power between a first rotationally movable element and a second rotationally movable element to provide a device which can provide, in a preferred form, continuously variable ratios, of angular velocity at an input to angular velocity at an output, within the range of ratios -1:1 to 0 to +1:1.

The present invention finds use in electronic, hydraulic or mechanical applications and, in a preferred form, provides variable input and output speeds; an output angular velocity that varies from 0 to $\pm$ the gear ratio as the input varies from zero to the input angular velocity; torque multiplication; the ability to vary speed and torque. Furthermore, the present invention provides multiple inputs and/or outputs and reduction, step up or 1:1 gear ratios. This invention includes the use of a planetary drive, that is a drive which includes a set of rollers, bearings or similar moveable parts, arranged in a circle around an axis and configured so that, through their movement in concert, apply torque to a body whose resultant rotation is used as the output of the drive. Examples of similar drives are described in Australian Patents 6007822 and 613927 as spin control differentials for vehicles and couplings. A planetary drive based on a sun gear, a ring gear a planetary gear and a planetary gear carrier is disclosed in Australian Patent number 465202 in the name of Eaton Corporation.

Examples of planetary drives are manufactured by Sumitomo Heavy Industries Ltd, Japan, under the name "cyclodrive".

Although planetary gears are known, the prior art gears have failed to take advantage of certain of their features, in particular, the contra-rotational nature of the input and output shafts.

It is a general object of one or more various preferred embodiments of the present invention to provide a device which can provide continuously variable output angular velocity to input angular velocity ratio; to provide a device which can combine more than one input angular velocity ratio; to provide a device which can provide one or more angular velocity output; to achieve this, sophisticated techniques involving integrating, balancing or heterodyning more than one rotational force by either mechanical or electrical means. The invention is capable of absorbing energy from or inputting energy to the output, thus providing regenerative braking or acceleration according to the power output demand. The effect of electronically controlling the self-braking of the contra-rotating magnetic discs produces the mechanical equivalent of the input forces causing a constantly variable output in speed with variable torque.

In a first embodiment, the invention resides in a variable ratio gear including:

a planetary gear and a variable brake;

said planetary gear including an outer body, at least one cage and a centre shaft;

a first means between said centre shaft and said cage;

a second means between said cage and said outer body;

wherein, upon rotation of said shaft, at least one of said outer body and said cage is caused to rotate;

and wherein said variable brake includes a variable load means supported between said shaft and said cage such that variation of a load between zero and a maximum value corresponds to variation of the ratio of the angular velocity of said outer body to the angular velocity of said shaft.

In a second embodiment, a planetary gear has a variable balancing mechanism between any of the main three components of the gear which will allow for combining one more rotational angular velocity, with or without the use of a variable brake so that rotation of any said

component will likewise cause rotation in at least one of the other components, providing one or more angular velocity output also with the choice of contra-rotation.

Preferably, the cage includes a plurality of fingers joined at one end to a common plate and there are a plurality of rollers located between the fingers. The outer body of the planetary gear preferably has a plurality of scallops on an inner surface adapted to receive the rollers. The drive shaft preferably includes an offset cam in sequential operable connection with the rollers such that rotation of the drive shaft causes the cam to sequentially rotate the rollers thereby rotating the outer body. The number of rollers differs from the number of scallops.

The variable brake may suitably be a magnetic load applied between the drive shaft and the cage. The maximum load applicable by the brake is preferably sufficient to lock rotation of the cage to rotation of the drive shaft.

Preferably, the variable brake is continuously and smoothly variable between zero load and maximum load. The load provided by the variable controller or brake may suitably be controllable by a feedback signal derived from a measurement of the angular velocity of the body, cage and shaft.

In another embodiment, the variable brake comprises two separate drives, one drive for the shaft and one for the cage, such that heterodyning of the drives produces an output angular velocity of the outer body. The separate drives can be applied to any two components of the variable ratio gear and the resultant output angular velocity will appear at the other components. Any source of initial power input can be used, eg, magnetic, hydraulic, manual, wind power.

In yet another embodiment of the invention, a fixed speed reduction or acceleration can be combined for such requirements as contra-rotation of two (or more) turbines

at either ends or opposite ends of a motor. Any type of feedback may allow the control of load sensing to equalize, using for example, fluid pressure.

In order to assist in further understanding of the invention a number of preferred embodiments will be described with reference to the attached figures in which:

FIG 1: illustrates the end-on view of an example of a planetary drive.

FIG 2: illustrates a side-on cross section view of one embodiment of the present invention.

FIG 3: illustrates a first embodiment of the present invention.

FIG 4: illustrates a second embodiment of the present invention, namely, two self-contained electric motors with integrated gear, having available electronic, or electro-mechanical biasing, ramping, or a type of "yo-yo" effect allowing the motors to operate at their optimum torque and speeds.

FIGS 5 - 18: illustrate other various embodiments and uses of the present invention.

In order to describe the present invention, it is first necessary to describe the operation of a planetary drive. FIG 1 shows a view, along the drive axis, of a planetary drive. Clamped to an input drive shaft (1) is a cam (3), clamping sufficient so that the cam does not slip on the shaft (1). Surrounding the cam is a circular arrangement of 8 rigid objects, referred to here as "rollers", which can move radially as allowed or forced by the cam. Maintaining constant angular separation of the rollers is an arrangement of 8 "fingers" which are all joined at one end and remain fixed relative to one another through connection at one end to a common body (6). The combination of the fingers and the common body (6) is referred to as the "cage". Surrounding the cage is the "outer body" (5), whose exterior is cylindrical

but whose interior wall has indentations or "scallops" whose purpose is to receive the rollers as they are pushed out by the cam. In FIG 1, the number of scallops is 9. In order to achieve movement of the outer body through rotation of the shaft (1) and the cam (3), the number of scallops must be different from the number of rollers.

In other examples of planetary drives, the rollers are referred to as "peanuts" and may be rigid slides or multiple rollers or may have axles, but the principle of operation of the drive remains identical . It can be seen from FIG 1 that, if the cage is held fixed so that it cannot rotate about the drive axis, the outer body will rotate one complete revolution for every 9 complete revolutions completed by the drive shaft and that the direction of rotation of the outer body will be identical to that of the drive shaft. Furthermore, it can be seen that were the number of scallops equal to the number of rollers, the rollers would quickly align with the troughs of the scallops and the action of the cam forcing the rollers into the scallops would not apply any torque to the outer body.

It should also be noted that were the outer body to be prevented from rotating about the drive axis with the cage left free to move, the cage would then rotate about the drive axis in the opposite direction as the rotation of the drive shaft and cam, and that the cage would complete one such revolution for every eight revolutions of the drive shaft.

In a further embodiment where there are more rollers than scallops, if the cage is held fixed about the drive axis, the outer body will rotate in the opposite direction as the drive shaft with some multiplication of the rotation which is defined by the numbers of rollers and scallops. Also, if the outer body is held fixed about the drive axis and the cage left free to move, the cage will rotate in the same direction as to the rotation of the drive axis, again with some multiplication of the motion which is defined by the members of rollers and scallops.

It can also be seen that if one or the other of the cage or the outer body is held fixed with respect to the drive shaft, that is, if one or the other is compelled to have the same angular velocity as the drive shaft, then the third body is also compelled to have the same angular velocity as the drive shaft. For example, when a clutch mechanism is installed in the planetary drive to keep the cage clamped fixedly to the drive shaft and the drive shaft is turned with some angular velocity, the outer body would also turn with an identical angular velocity.

For the sake of further explanation of this invention, consider the rotation of the outer body to be the output of the system. Also, consider that the planetary drive is one in which the number of peanuts or rollers is smaller than the number of scallops in the outer body. In such a system, the drive will transmit some mechanical power, supplied at the input to the system via the drive shaft, to some mechanism attached either directly or indirectly to the output. The mechanism so attached to the output will load the drive, and will be called the load. If such a load is large enough that it overcomes frictional torques within the drive and the drive shaft is rotated, the output will remain stationary and the cage will rotate in the direction opposite to that of the drive shaft if allowed to do so. If, on the other hand, the cage is forced to rotate with the same angular velocity as the drive shaft, the output will also rotate with the same angular velocity. Supplying mechanical power to a load which is initially at rest can place unwanted strain on the devices providing the mechanical power to the input of the drive.

So far, two extremes of the situation have been considered. There is a continuum of intermediate conditions which can be instituted by applying torque to the cage which opposes that torque which makes it spin in the direction opposite to that of the direction of the spin of the drive shaft.

Consider again the situation in which a substantial load is attached to the output and the cage is left free to spin. If the drive shaft is rotated, the output will remain still and the cage will rotate in a direction opposite to that of the shaft. If, now, a

opposing torque is applied to the cage which causes some reduction of its angular velocity while the angular velocity of the drive shaft remains substantially constant, the output will begin to move in the same direction as the drive shaft. the angular velocity of the output, with constant angular velocity of the drive shaft, is determined by gearing within the planetary drive and the amount by which the backward rotation of the cage is retarded. The magnitude of the retarding torque is a continuum, so the apparent gearing ratio, that is the input angular velocity compared to the output velocity, also appears as a continuum.

If enough retarding torque is applied that the cage stops spinning, the gearing ratio would be that which is directly calculable through counting the number of scallops and cam peaks, the number of peanuts of rollers does not generally enter into this calculation. If even more "retarding" torque is applied to the cage so that it begins to rotate in the same direction as the drive shaft the angular velocity of the output increases still more. If the retarding torque is increased so that the cage and the drive shaft have the same angular velocity the angular velocity of the output will be the same as that of the drive shaft.

It is also possible to apply enough positive torque so that the cage over-runs the drive shaft, that is, the cage has angular velocity greater than that of the drive shaft. This will cause the output to rotate with an angular velocity which is greater than that of the drive shaft.

It is possible to obtain an accelerated output either by applying multiple inputs to any of the three components of this gear, (as described in the windmill operation, pages 11, 12 and harmonic heterodyning) or by applying an opposite torque to the cage relative to the outer body in order to accelerate the cam.

By using the present invention, a continuously varying turning ratio of the output drive shaft compared to the input, can provide the range of ratios from -1:1 to 0 to +1:1.

In this embodiment of the invention, FIG 2, this control is effected by introducing a magnetic brake (10) which is used to couple the motion of the drive shaft to the cage, using some of the torque supplied by the drive shaft to be the retarding torque applied to the cage. The amount of coupling between the drive shaft and the cage can be varied by varying the current supplied to the electromagnets of the magnetic brake, the more current applied, the greater the magnetic fields generated by the electromagnets and the greater the eddy currents produced in the cage. The eddy currents in the cage produce their own magnetic field which couple with the magnetic fields of the electromagnets and in doing so couple torque to the cage which is in the same direction as the angular velocity of the drive shaft. This is the retarding torque.

Further to this embodiment, there is a variable "throttle" whose position indicates the desired final speed of the loading mechanism attached to the output. The position of the throttle is measured in such a way that its position is indicated by an electrical signal. There is also a speed detector which measures the instantaneous speed of the loading mechanism. The source of driving torque is a synchronous electric motor which has a current detector attached to its source of electrical power to provide a measurement of the instantaneous current being drawn by the synchronous motor. A synchronous electric motor is one which is best operated such that its output shaft turns at a constant speed, or angular velocity. This invention allows the use of such a motor even though the device has a continuous variable output angular velocity.

The measurements of the throttle position, the speed of the load and the current being supplied to the synchronous motor are fed as electrical signals to an electronic device which provides an output signal which controls the amount of electrical current supplied to the electromagnets of the magnetic brake. That is, the output signal controls the amount of coupling of the torque of the drive shaft to

the cage. This feedback system is set to keep the angular velocity of the synchronous motor close to its optimum value while the load accelerates to the desired final speed.

A description of a typical accelerating sequence will now be given. With the load at rest, the synchronous motor is turned on and allowed to attain its optimum angular velocity with no controlling current applied to the electromagnets of the magnetic brake and therefore with no coupling between the drive shaft and the cage. As the motor gains speed, the cage spins with increasing angular velocity with a direction opposite to that of the drive shaft. Assume now that the throttle is moved to a position which indicates that the desired maximum speed of the load corresponds to that attained when the angular velocity of the output of the planetary drive is equal to that of the drive shaft.

The feedback mechanism produces a signal which causes a certain amount of electrical current to be supplied to the electromagnets of the magnetic brake which couples a retarding torque to the cage. As the angular speed of the cage falls, due to the retarding torque, the output begins to move causing the load to accelerate. The brake is thus acting like a slipping clutch at this point. The load which is now placed on the synchronous motor causes its angular velocity to decrease, an effect which is measured by the current detector attached to the source of electrical power. If the loading of the motor is too great, the feedback circuit causes the current to the electromagnets to be decreased, lessening the coupling of the drive shaft and the cage, in turn reducing the loading on the output.

If, on the other hand, the motor is operating at an angular velocity which is somewhat greater than its minimum, the feedback circuitry provides a signal which increases the current supplied to the electromagnets, increasing the coupling between the drive shaft and the cage and increasing the angular velocity of the output. In this manner, the load is accelerated whilst the synchronous motor is never over-loaded.

In this embodiment, the acceleration continues until the angular velocities of the drive shaft and the cage are as close as possible except for the inevitable slight "slipping" of the magnetic brake.

By connecting a further system to the output shaft, or by using the output shaft itself, it is expected to effect magnetic braking for speed control or governing, or for the return of energy to an electrical accumulator system during a cycle of magnetic braking.

It will be understood that any driving source such as combustion or other motors can similarly benefit using this system so that the optimum speed for the source can be used. It may therefore be required that other forms of load sensing such as load cells be employed to obtain the feedback needed to control the amount of magnetic coupling needed.

The effect of biasing the output of a mechanical system would be easily achieved using this planetary gear as outlined in this patent. One driving motor would provide the D.C. bias or constant component of the output drive while another could be attached to one of the other elements of the gear and add or subtract from the angular velocity of the output. Indeed, the variable speed motor drive as outlined above is an example of such a biasing system if the magnetic brake is considered as a form of electric motor.

Heterodyning of the two varying input angular velocities to produce one varying output angular velocity could be easily achieved by controlling both input velocities by means of separate motors. This could produce a cyclical "beating" effect in the output of the system, or a less cyclical output, depending upon the harmonic components of the inputs.

The planetary gear shown in FIG 1 and FIG 2 provides for one set of rollers (7) and one cam but there is the ability to equalize and balance the gear for smoother and

more powerful operation by the addition of one (or more) sets of cams (3) and rollers (7) which may also be used within the same outer body or bodies (5) and scallops (9). The increase in surface to surface contact thereby gained is expected to be an advantage in both high speed or low speed requirements. The cams could be related to each other at any angle within 0 to 360º of each other to provide maximum efficiency.

Multiplication of the gear ratios can also be added to the previously mentioned ratios, with the addition of a second cage (6) and a second set of rollers (7). The cage would be directly connected to the second cam (3) thus providing a multiplication of 1:64 ratio in the examples shown in FIG 1 and FIG 2 and can be designed to be used at the same time as any of the other ratios. The rollers (7) may be tapered as may also the outer body scallops (9) in order to allow for wear or reduce noise, spring loading could also be combined.

Another application is seen in a windmill which can be efficiently operated with a greater range of wind speeds than windmills with similar output powers. The windmill has two turbines for the conversion of wind energy into rotational mechanical energy, one of the turbines being joined fixedly to the drive shaft of a planetary gear assembly and the other turbine being joined fixedly to either the outer body or the cage of the planetary gear assembly. The rotational axes of the turbines are co-linear with the rotational axes of the drive shaft, the cage and the outer body of the planetary gear. The turbine connected to the drive shaft would be of substantially lesser diameter than the other turbine. An output shaft is connected to either the cage or the outer body of the planetary gear assembly, whichever is not joined to the larger turbine.

In one embodiment of this system, the turbines would have pitches of their respective blades arranged so that, with a wind driving both turbines, the turbines would counter-rotate. The larger of the turbines is joined fixedly to the outer body of a planetary gear assembly which is of a type whose outer body will rotate in the

same direction as the input shaft and can rotate when its cage is held still with respect to the ground.

In a light wind and with a loaded output, many windmills fail to turn because they cannot produce enough torque at their outputs to overcome the inertia and static friction within their loads and bearings of the turbines. In the windmill embodiment of the present invention, the planetary drive is designed so that its drive shaft has a large mechanical advantage over its output when its outer body is held stationary with respect to the ground. In a light wind the smaller turbine will begin to rotate and the planetary gear will begin to apply torque to both the larger turbine and the output shaft. One or the other or both of the larger turbine and the output shaft will begin to rotate due to the torque thus applied. If the larger turbine rotates under the influence of this torque, it will rotate in the same direction as the smaller turbine, that is, in the opposite direction to which it would rotate under the influence of any torque produced by the action of the wind on its blades. This will produce a braking effect on the larger turbine, slowing its rotation and in turn applying more torque to the output shaft. In very light winds this braking effect will not be enough to completely halt the backwards rotation of the larger turbine and the smaller turbine will therefore not be halted by the resistance of the load.

As the velocity of the wind increases, more torque is applied to the input shaft by the blades of the smaller turbine and more torque, in the opposite sense, is applied to the outer body by the blades of the larger turbine. At some wind velocity the torque on the larger turbine, produced by the action of the wind upon its oppositely pitched blades, will be enough to cause it to stop or even begin to turn in the opposite sense to the rotation of the smaller turbine. The varying angular velocity of the larger turbine changes the ratio of the output shaft to input shaft rotation from 0:1 when the output shaft does not move to X:1 as the output shaft begins to move, where X is a continuous variable which can actually exceed 1.0 if the larger turbine rotates quickly enough. Useful mechanical drive can be achieved with this windmill

over a large range of wind velocities as it can be designed such that the turbine to output mechanical ratio varies continuously as the velocity of the wind changes.

However, applying the well known advantage of simply contra-rotating two propellor blades using the cam output on this gear to provide an accelerated output could be used.

The prior art describes examples of using such a gearbox and there are several basic principles involved, within the variable speed drive. However, a secondary principle can enhance this gear which is the ability to incorporate huge advantages through the inclusion of a harmonic hetro-dyning of the relative drives. To attempt to achieve, for example, standing waves, and a much higher efficiency, several different ways may be used, by choosing the best R.P.M. such as, for example, using a 6:1 ratio with the windmill gear ratio and combining a propellor design and size which will match. Another way would be to incorporate a second driving motor as well as the magnetic brake previously described, then running it at the best speed to achieve as close to a standing wave effect of frequency as possible, likening it to having three motors.

In other embodiments, the magnetic brakes on the previously described magnetic drive can be designed to drive at some suitable speed which would be calculated to suit, providing harmonic hetro-dyning or a biasing ability.

There are many different ways and applications that can incorporate this harmonic system in any of the applications.

Another application for this gear would be with the use of extremely versatile and accurate measuring systems where the multiple shaft turning can provide up to a three way measuring system providing three way torque curves - either manually operated, or computer controlled, stepping motors or simple reversing motors could provide extreme accuracy combined with fast operation. In one method, by choosing motor operation, one motor could add and subtract acting like a biasing motor whilst the other could provide extreme accuracy.

Another every day application for this gear is expected to be an everlasting, super efficient clutch for vehicles for example by accelerating the centre shaft providing a more efficient clutching action.

The concept of using the planetary drive in such a way that all three of its major elements, that is the input shaft, the cage and the outer body, is a cheap and compact way of bifurcating the angular motion of a system. Conversely it can also be used to combine the angular motions of two separate systems into one output. The distribution of the torque in the bifurcating system can accurately be controlled through the use of clutching or braking systems to restrict the motion of one output and, in doing so, produce a greater or lesser torque at the other output. The clutch or brake can be configured to return inertial energy to the input so that it may be produced at the output at some later time.

Another application is expected to be the use of this gear for infinitely variable speed drives for vehicles such that the third output provides a balancing regenerative power source which can add to the driving motor power. Any of the three outputs can be used so that the energy can be stored in either a flywheel or combined with other useful power requirement such as generators or superchargers or similar. When the vehicle is coming to a stop, the braking can propel this storing system automatically or manually. On acceleration, this stored energy is added to the main driving power. While stationary, the main motor may propel the stored energy system through the planetary drive because the brakes are on.

A simple coiled spring could be used in applications where only a short torque advantage is needed to, for example, give a load a kick-off.

Using the feedback or biasing ability, a lighter load may be lifted faster automatically and can be designed into a robotic ability to perform useful reactive actions as well as to bend the elbow of an arm as the load increases.

By design choices of gear ratios, input and output R.P.M. heterodyning could significantly increase the efficiency of not only the above drive but also many other simpler uses.

The main power source can be any type of engine, machine or manual power. The high efficiency achieved by this system would be particularly beneficial to battery or solar powered systems.

There are many variables to the above system for magnetic control that would still come within the scope of this invention such as the use of metal filings suspended in a liquid or other medium used to actuate the clutch.

In yet another form of this invention, liquid polymers or similar may be used and may be controlled in any way to provide the above clutch action, such as changing their viscosity or density by varying voltage, current, temperature, centrifugal force, compression, or other molecular controlling means.

All the above described systems may be applied to any type of drive, motor, engine, machine, or manual operation.

In another form of this invention, exercising or body manipulatory or gymnasium equipment could equalize loading requirements using this gear to more effectively provide proportional leverage, for equalizing, balancing and the reduction of size.

In one example, very heavy weights must at present be used to provide a certain inertia combined with loading and cannot be duplicated by compressing springs, etc, whereas this gear could be used and in one method accelerate the cam drive

(which could be lifting a small adjustable weight, swinging a pendulum or governor) by manually levering the cage gear toward (or away) from the outer body of the gear.

Rowing action could also be duplicated by the above action which could even have an impellor rotating in a container of water to simulate the sound and kinetic effect.

In another form of this invention gates, heavy lids, mattress, bed and patient lifting equipment can be manually levered apart at their pivot points providing extremely compact drives as there is great difficulty in providing power drives to this type of equipment.

The compact design of this planetary drive allows for a compact drive for contra-rotating drives for fans, propellers. The ratio can be any of the three chosen ratios in most cases it is expected that the input from the driving motor would drive the cam and the two output propellers would be on the cage and outer body. The blades would be designed in such a way that balancing would automatically occur.

The ability to store reactive energy within the windmill described on page 11 allows the increase of the duty cycle. Before the wind is strong enough to move the load, one propeller could force the other to gain momentum opposite its normal rotation providing added torque the moment the wind increases to a point forcing the other blade to slow down.

This gear provides the ability to have a viable economic drive or a compact contra-rotating drive. This gear can provide contra-rotating propellers in aircraft or can be

fitted easily now to stop the problems of gyroscopic torque reaction properties caused by 'prop-wash' which can cause the aircraft to roll.

Propellors on fans and any fluid passing equipment can be made more efficient with this gear either in variable speed mode or in its contra-rotating ability, not only because contra-rotation is known to be more efficient in wind tunnel testing but because this drive can be made physically much smaller to restrict less of the fluid, gas or wind. High speeds and frequencies can be achieved because of the simple gear design.

Boat propellors can be made more compact and the varying of speed more easily achieved with this gear plus the gear has the ability to contra-rotate and balance automatically. If required the gear may be below the water level because of the ease of sealing this self-balancing propellor gear.

This gear has the ability to provide a number of advantages in mechanical operations, for example, such as relating one wheel to another for equalizing torque or differential action, or where one multi-drive or motor is required, or for four wheel steering. Another use is the ability of fitting a clutch to manually over-ride a motor driven auto-pilot on a boat, and will also allow easier installation of 'add-on' auto-pilots themselves, as it is very difficult to find the space to fit a motor drive to the wheel on most vessels. The added ability of being able to manufacture from non-corrosive materials in sea air equipment is a major advantage.

Another application of the gear with two contra-rotating elements with different angular speeds is in the dispertion of fluids as spray for purposes such as crop spraying. The cage and the outer body could be caused to rotate contrary-wise

each with a turbine attached. Fluid could be forced out through nozzles, which exit the gear between the two turbines. The turbulence created between the two turbines would be used to atomize and finely distribute the fluid before it is ejected from the region of the turbine toward its target, producing a more even coverage of the target with the fluid than is possible now. The planetary drive would thus be a much more compact way of achieving this result than using sets of gears as is currently necessary.

Any contra-rotating machinery requiring the passage of fluid or other substance to activate and control the speed of the drive outputs can be fed into a central hole or orifice within the center shaft. The orifice may be coupled to internal grooving within the gear in order to distribute fluid directly around the contra-rotating output vents in order to spray crops or equalize spreading or spraying of substances. Alternatively, a fluid hole may pass right through the gear in order to transfer the substance.

The ability to provide multiple integrated drives for example on ride-on mowers, the 6:1 ratio and 7:1 ratios could drive two contra-rotating cutting blades, plus the wheels could be driven at, for example, 36:1, all from one gear unit directly mounted on and connected to the motor shaft.

The variable (or fixed) speed gear is a self-contained three dimensional, geared drive, with controllable ratios and built-in "no load" start or clutch with automatic sensing if required.

Compared to existing gearing systems the variable speed (or fixed speed) gear will give the following benefits:

- Extremely efficient – up to 98%.
- Low friction with low wear.
- Easily mounted as it does not need critical driving or driven mounting supports.

- Can also be made of various materials such as plastics, ceramics, self lubricating materials, brass, bronze, inert tantalum, sintered steels or alloys, almost any material, and almost any manufacturing process such as cast, laser cut, machined. The designs can be very complimentary to be used with advanced technology in materials and manufacturing.
- Can be made in varying sizes to suit many situations.
- Can be completely sealed for medical or underwater use.
- Some designs only about 1/4 the size of others.
- Can be controlled in many ways to provide a variable speed much more efficiently than conventional methods of trying to accelerate a loaded motor up from a stopped position. The driving motor can be up to full speed, before the load is applied.
- Has an in-built ability similar to doubling leverage.
- Has a feedback option.
- Has a freewheeling option.

Yet further applications of the present invention include:

AUTOMOTIVE

Variable speed gears could greatly simplify the present automatic gearbox. With the use of an electronic control (or other variable control) will enable smooth acceleration from motors with barely any perception of gear change.

ELECTRO-MECHANICAL

Any system having high start up torque at low angular velocity will benefit from this variable speed drive.

An example here is the lift industry. Currently thousands of dollars are being spent on elaborate speed controls in many cases even requiring special motors designed specifically for the purpose of smoothly driving lifts. Smaller motors could be used in conjunction with this variable speed control either with an electronic type of control, or various other types of variable control. This would mean costs would be dramatically cut and still maintain smooth control of the drive system of the lift.

AERONAUTICAL

Smaller more efficient gearing would reduce weight and reduce friction in drive trains for aeronautical mechanicals. Vibration would be improved as well. Helicopter engine gearing would benefit substantially from this variable speed gear. Lightweight and maximum efficiency would benefit the space industry.

MEDICAL

Implantable orthopedic prosthesis could incorporate miniaturised variable speed gears, ie. for skeletal movement in joint replacement. Materials could be inert tantalum, and together with a sealed gear would enable efficient performance.

MARINE

Gearing boat engines that give high torque could be easily met by the variable speed gear resulting in smaller size and better control. Small outboard motors through to big diesel engines would benefit with improved performance and reduced vibration and better frictional co-efficiencies.

INDUSTRIAL

Any system employing the variable speed gear would benefit from extra strength, especially in start up, high torque situations, and with ongoing efficiency and energy conservation. Low maintenance and lower manufacturing costs are other benefits.

DOMESTIC

Domestic products that are petrol, diesel or electrically driven would all benefit, particularly in the ecological area with the ongoing efficiency resulting in reduced energy consumption.

AGRICULTURAL

Reduced cost of manufacture, improved efficiency and reduced energy usage are all benefits offered by the present invention.

ROBOTICS.

Reactive touch sensitive control for robotics is possible by using the present invention..

ADVANTAGES OF USING THE GEAR

The multiple geared motors FIG 4, can either be fully self-contained or able to be integrated with external rotational forces, in some instances may be combined within, for example, a combustion motor (or other rotational source) crankcase and/or sharing the same shaft and /or lubrication Fig 7,8,10. Alternatively it may support the wheel (or load). Some optional additional design features follow on page 22 - 23.

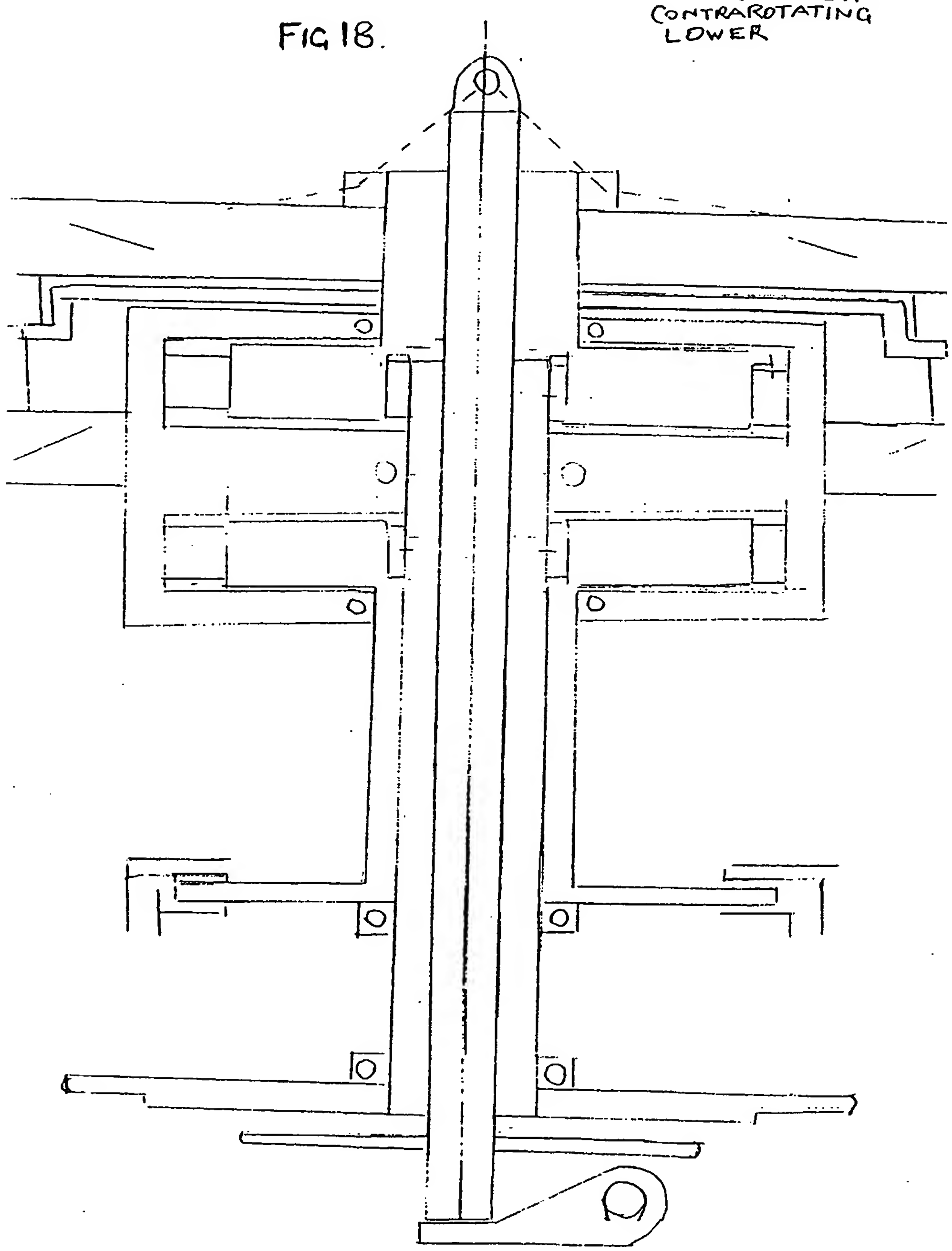
FIG 9 shows a system for simulation and a method for choosing complimentary designs or for the manufacturing requirements for the rotational forces..

Integration of this gear with alternative, for example, hydraulics drive systems can overcome common overheating problems The same integration can apply to the following train designs as optional alternatives.

1. Trains often use multiple electric (or diesel) motors, these motors can be allowed to come up to any optimum speed (or synchronous speed) before the load is applied.
2. The freewheeling ability of this gear can allow the motors to switch off when not driving. Power savings alone, perhaps over 70% or more should be possible if multiple motors are switched off.
3. The ability to retain an added braking system when switched off can be retained, if needed, by double acting magnetic brakes. This provides safer transport.
4. The gear provides integration with optional automatic load sharing or load distribution.

FIG 18.

SWASH:
CONTRAROTATING
LOWER



MALCOLM DEAN REF. FIG.4 14-10-97
REF. ALSO FIG. 6.

FIG. 17 REF FIG. 15B

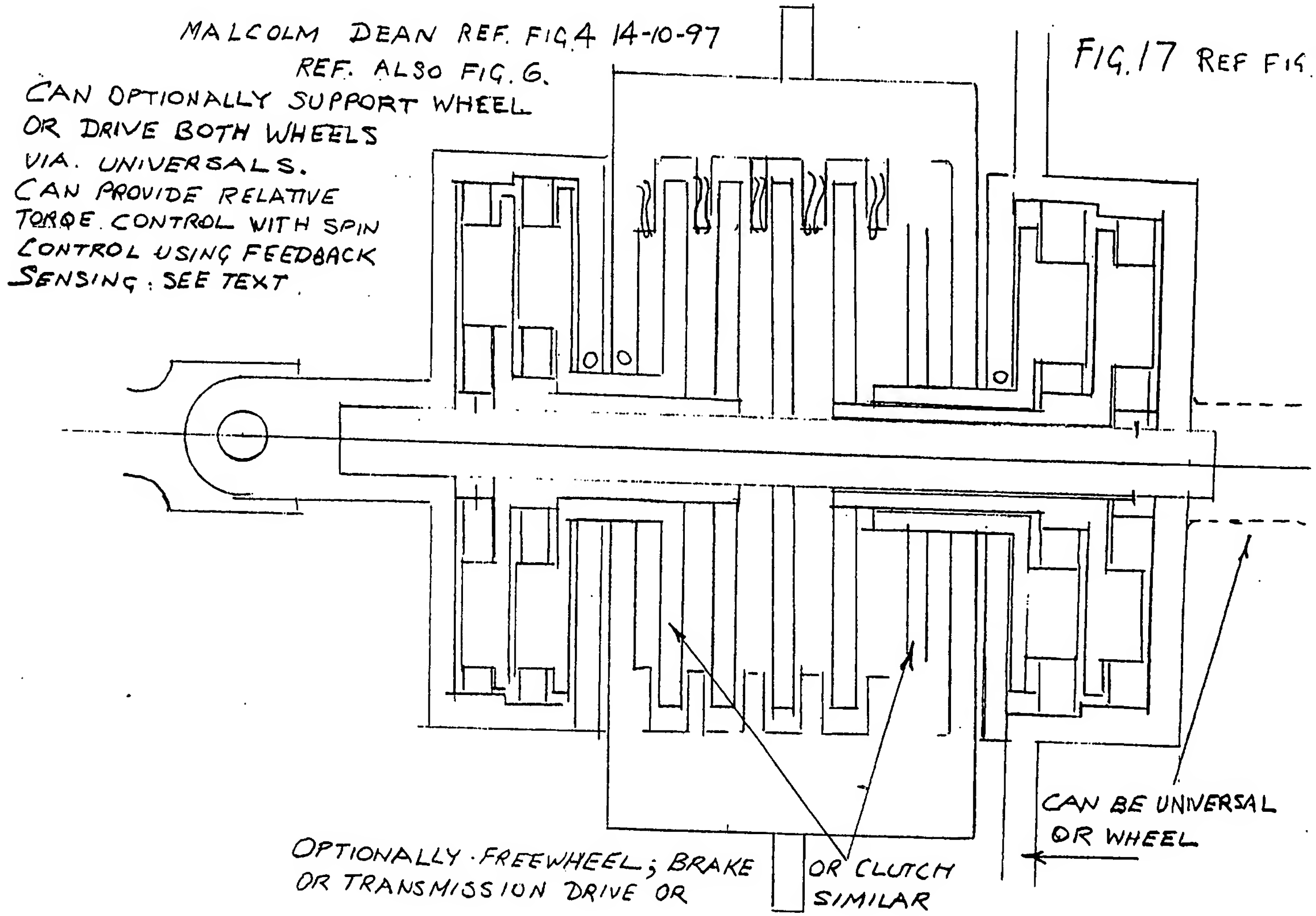


FIG 16 A

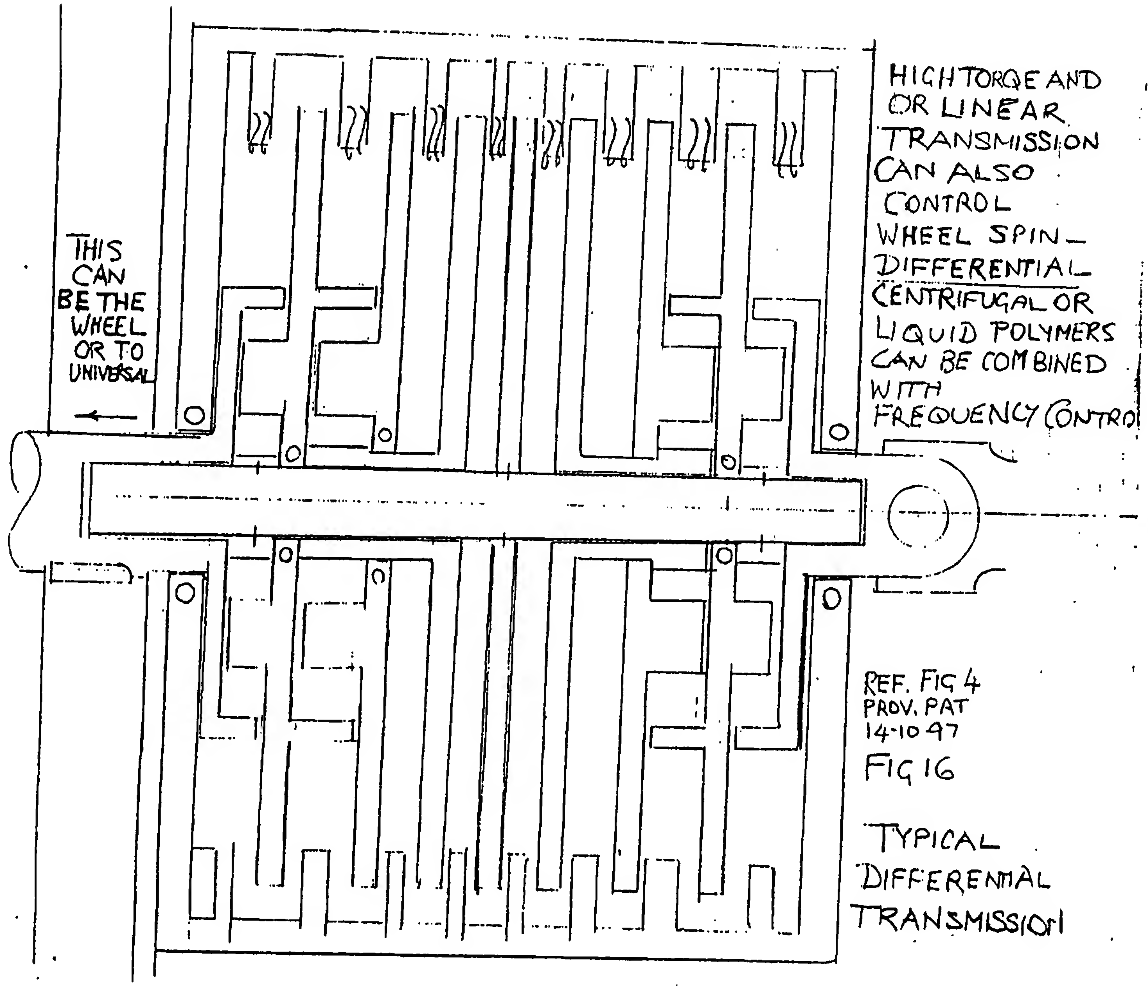
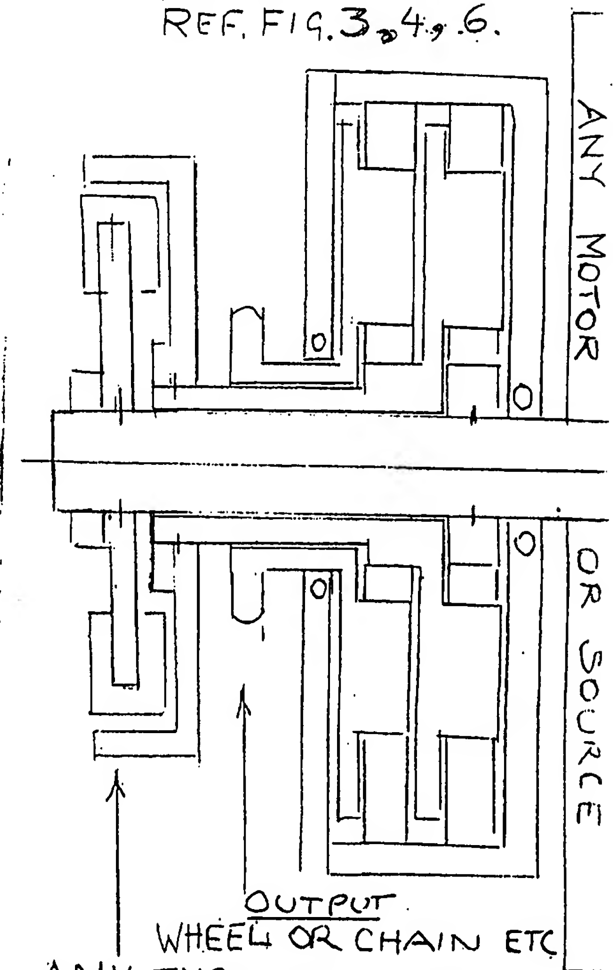


FIG 16 B
REF. FIG. 3, 4, 6.



©MALCOLM DEAN FIG.15A

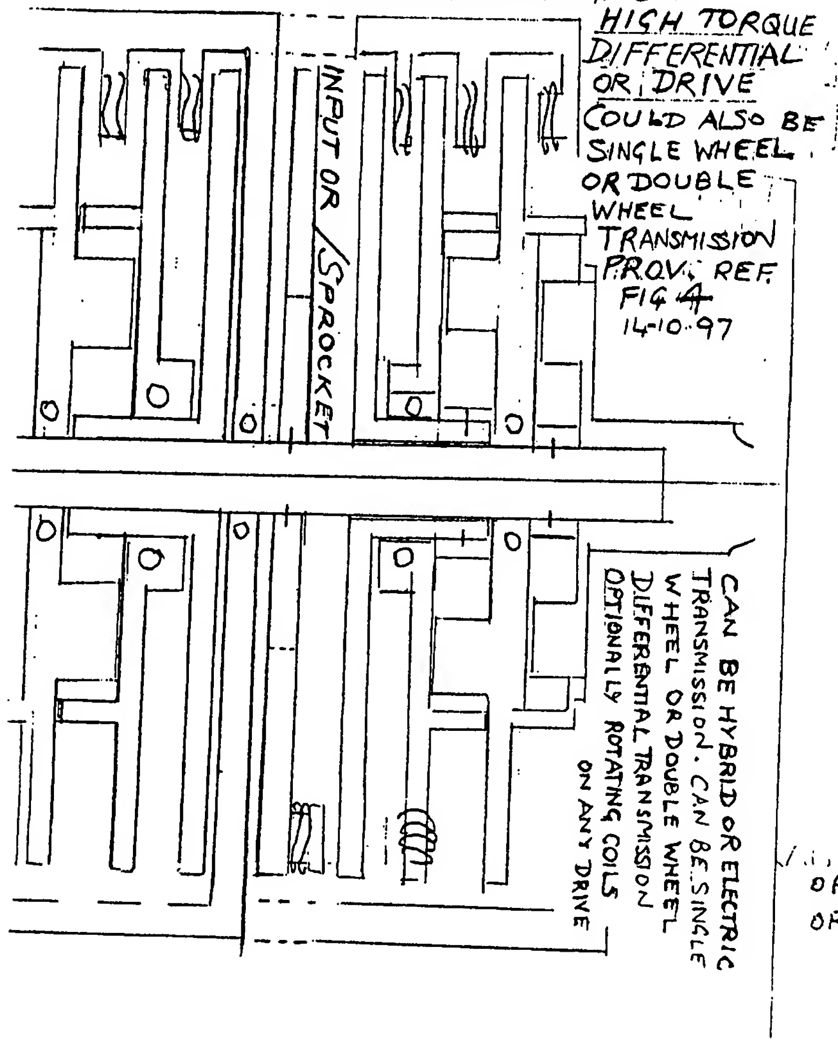
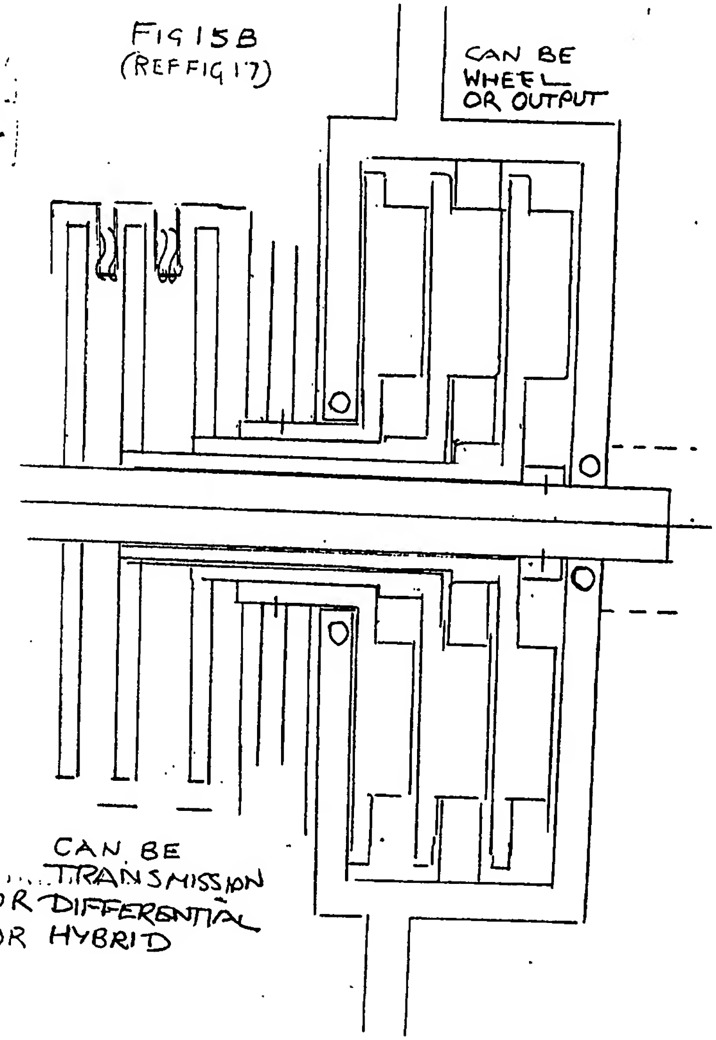
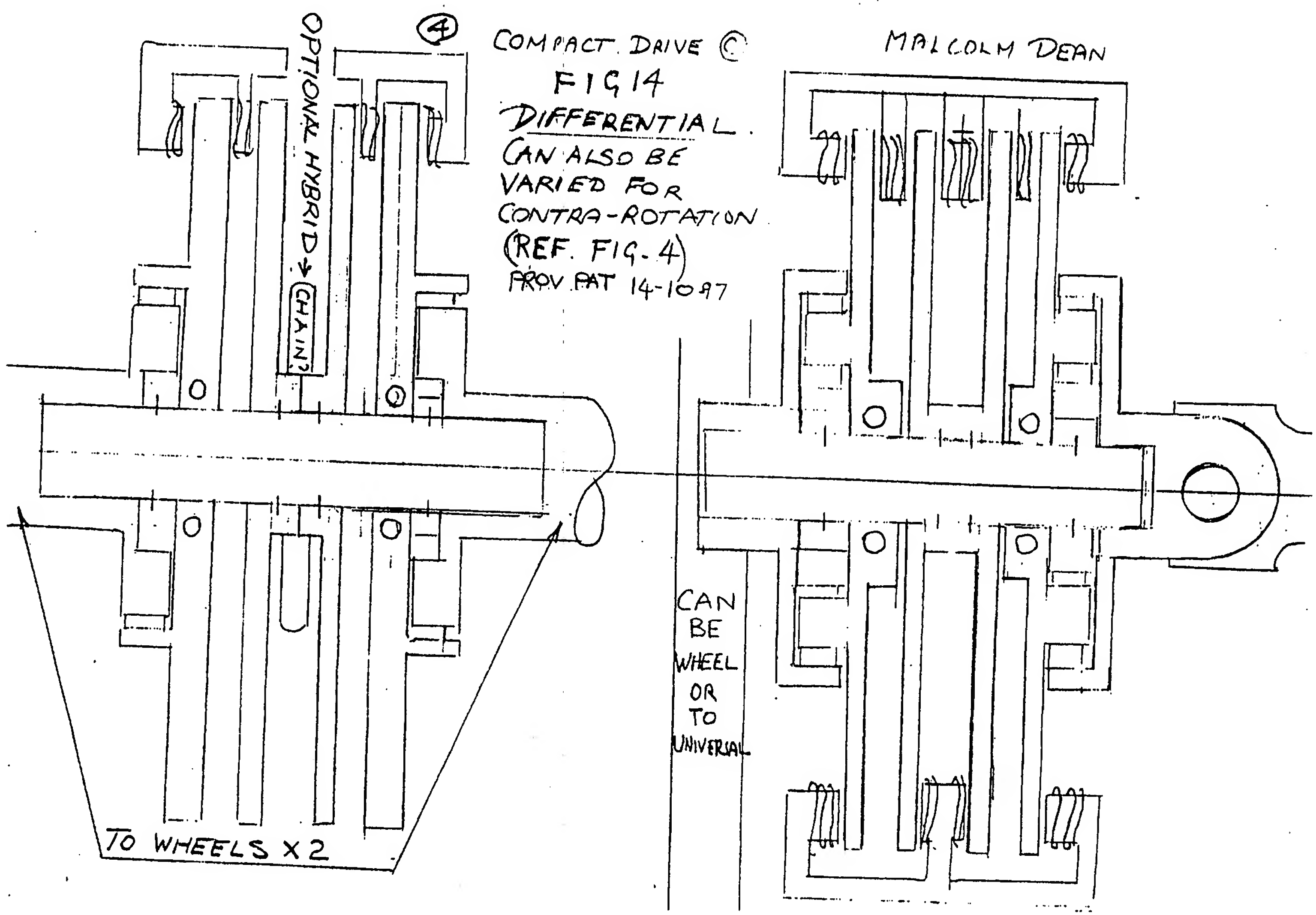


FIG 15B (REF FIG 17)





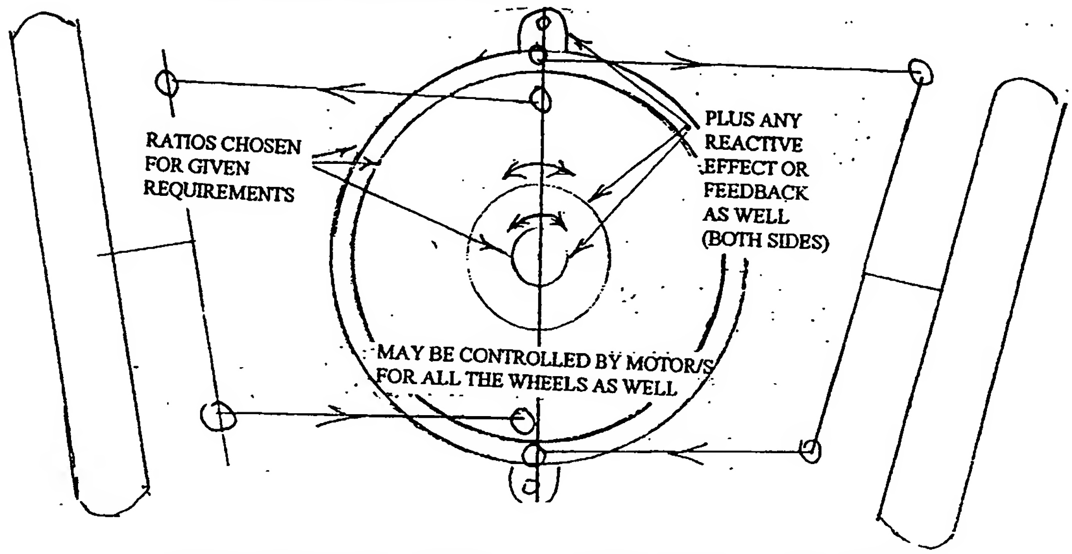
COMPACT DRIVE ©
FIG 14
DIFFERENTIAL
CAN ALSO BE VARIED FOR CONTRA-ROTATION (REF. FIG. 4)
PROV PAT 14-10 97

FIG 12

LIKE RIDING A MOTORCYCLE Malcolm Dean ©

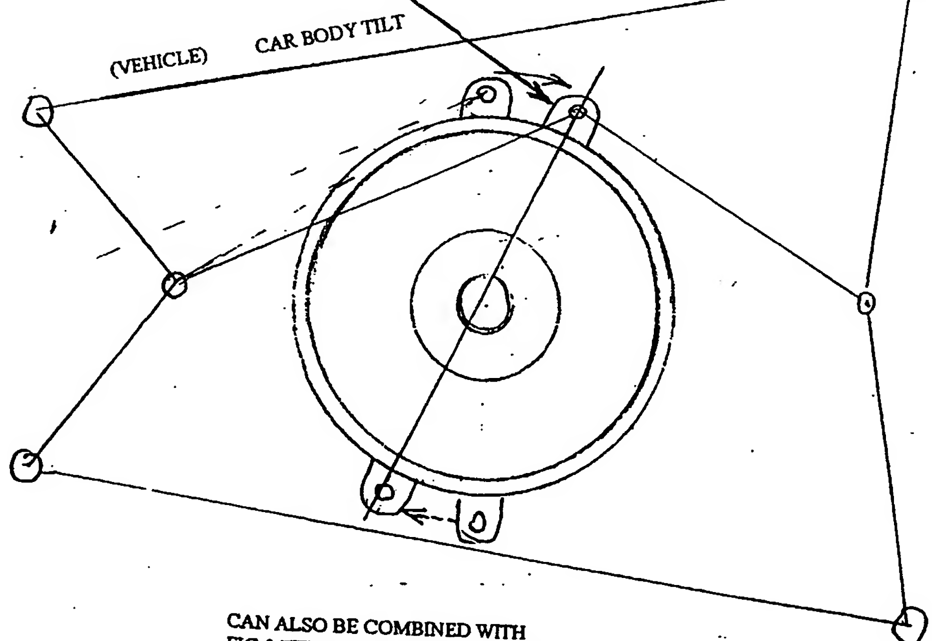
ANY MOBILE ON LAND, SEA OR AIR CAN PROVIDE - PASSENGERS OR CARGO

THIS TILTING CAN BE DONE WITHOUT THE GEAR, HOWEVER THE DOUBLE CONTRA-ROTATION CAN PROVIDE CONTINUOUS CORRECTION OR OTHER REACTIVE MOVEMENTS AS WELL



RATIOS CHOSEN CHOSEN TO MATCH THE FEEDBACK WITH THE FORCE REQUIRED

ALSO THE BODY OF THE GEAR IS NORMALLY FIXED - BUT IF ALLOWED TO IT COULD BE ROTATED LIKE THIS: (EITHER WAY)



CAN ALSO BE COMBINED WITH FIG 5 STEERING GEAR TO CORRECT CASTER AS WELL.

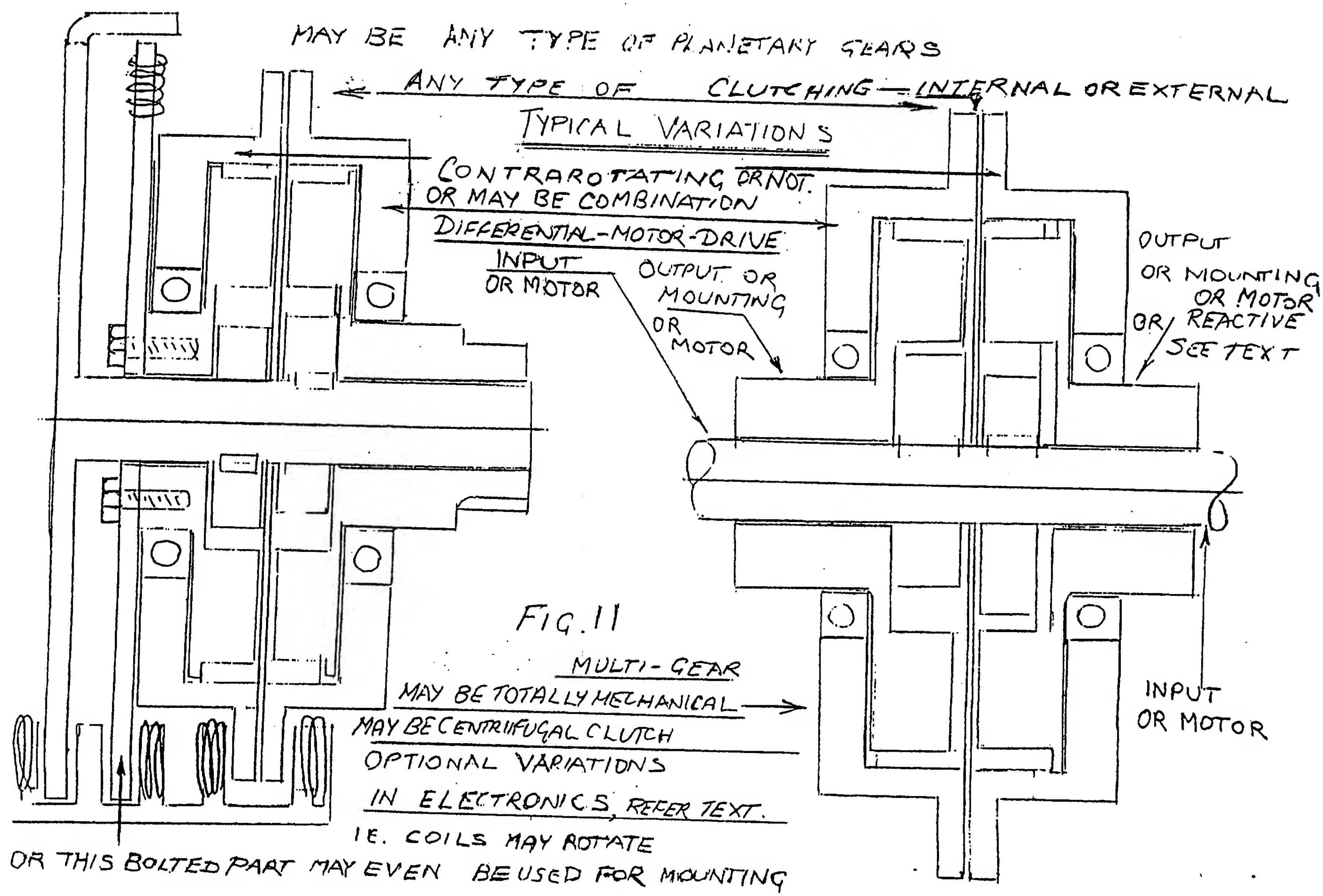
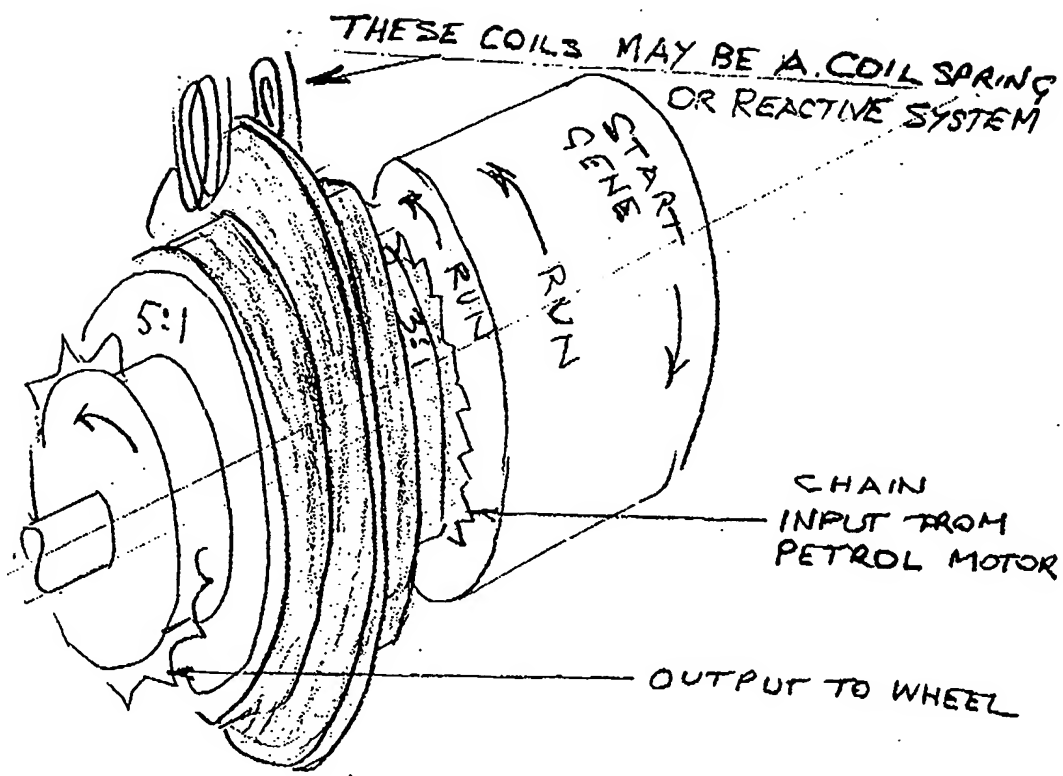
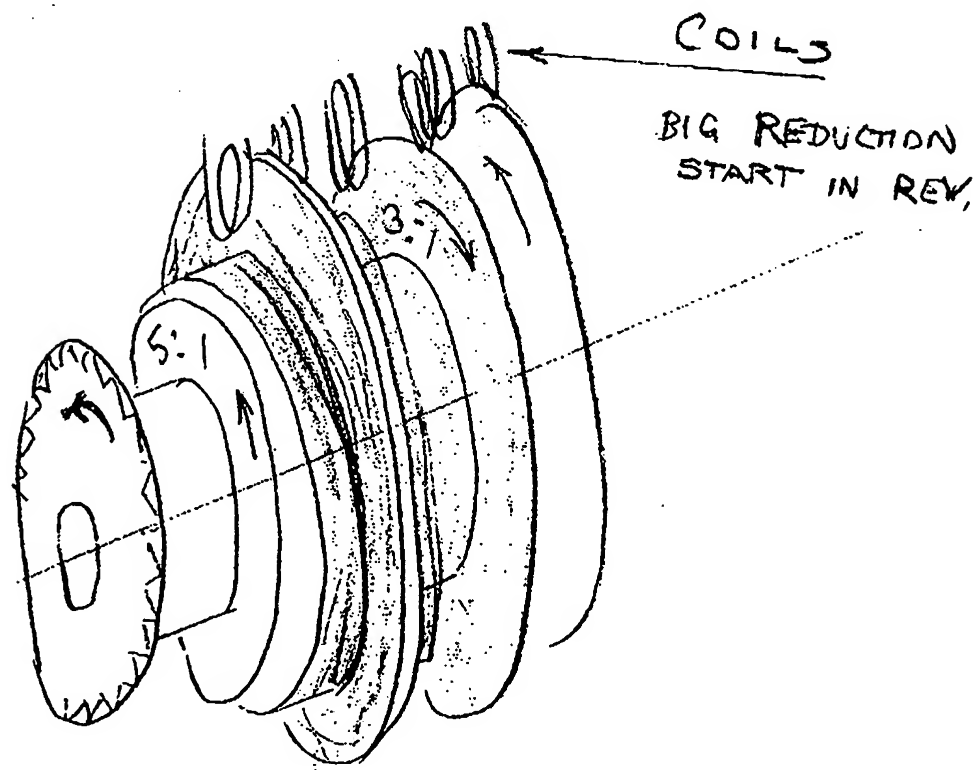
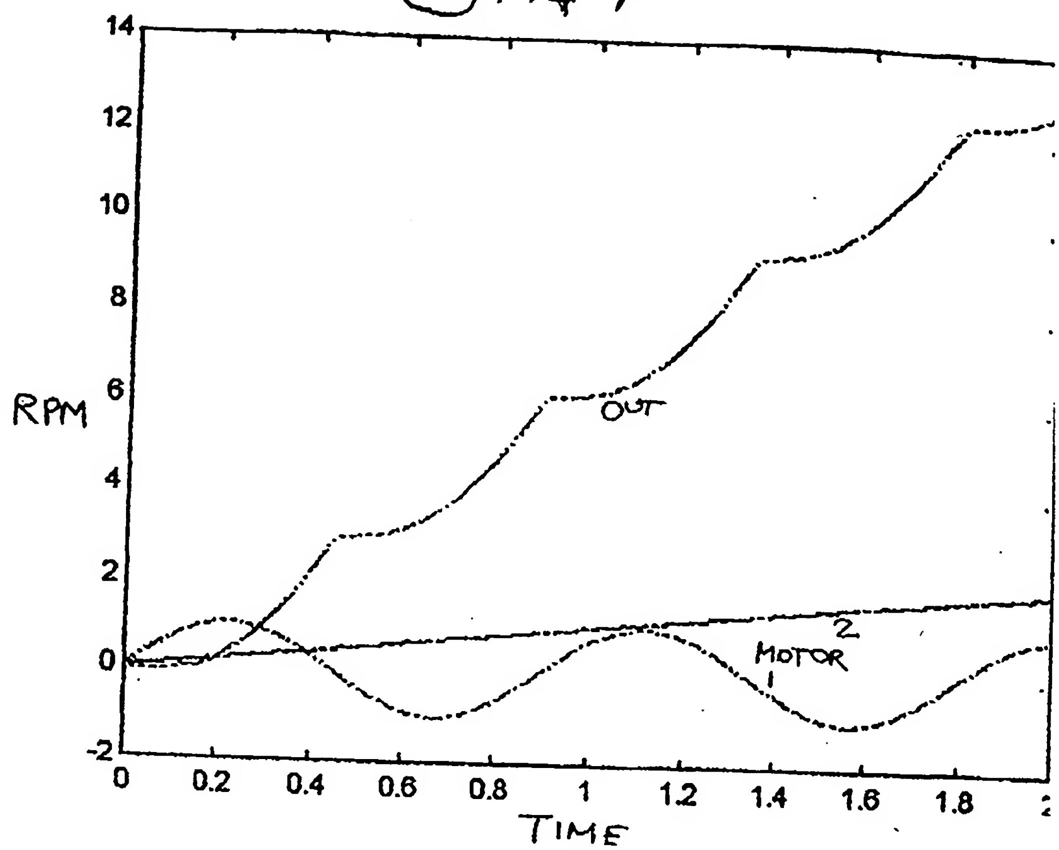

MAY BE ANY TYPE OF PLANETARY GEARS
ANY TYPE OF CLUTCHING — INTERNAL OR EXTERNAL
TYPICAL VARIATIONS
CONTRAROTATING OR NOT.
OR MAY BE COMBINATION
DIFFERENTIAL-MOTOR-DRIVE
INPUT
OR MOTOR
OUTPUT OR
MOUNTING
OR
MOTOR
OUTPUT
OR MOUNTING
OR MOTOR
OR REACTIVE
SEE TEXT
MULTI-GEAR
MAY BE TOTALLY MECHANICAL
MAY BE CENTRIFUGAL CLUTCH
OPTIONAL VARIATIONS
IN ELECTRONICS, REFER TEXT.
IE. COILS MAY ROTATE
OR THIS BOLTED PART MAY EVEN BE USED FOR MOUNTING
INPUT
OR MOTOR

FIG. 11

FIG 10


THESE COILS MAY BE A COIL SPRING OR REACTIVE SYSTEM
START GENE
RUN
RUN
5:1
3:1
CHAIN INPUT FROM PETROL MOTOR
OUTPUT TO WHEEL


COILS
BIG REDUCTION START IN REV,
3:1
5:1


14
12
10
8
6
4
2
0
-2
RPM
OUT
MOTOR
2
1
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
TIME

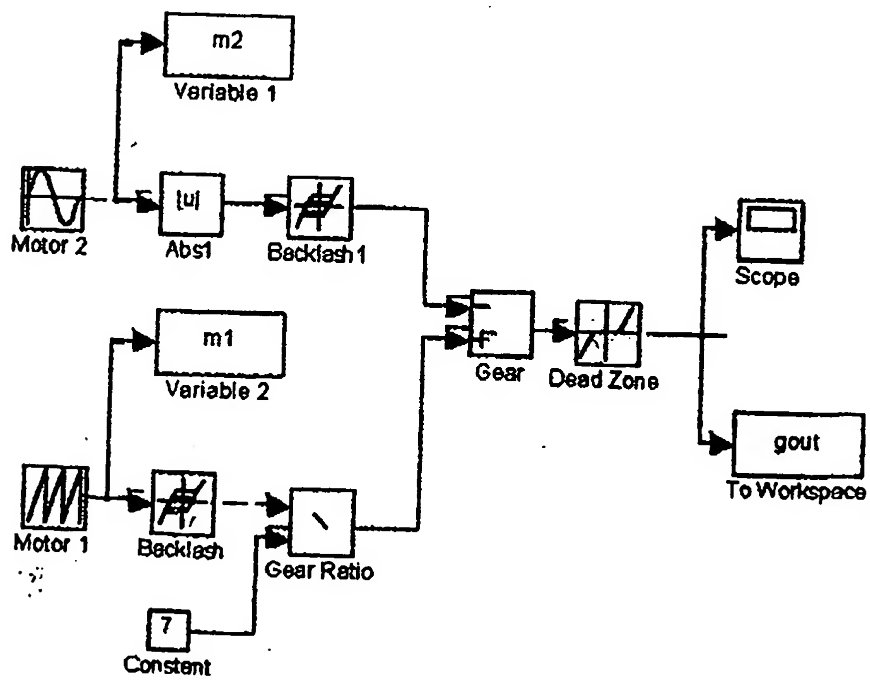
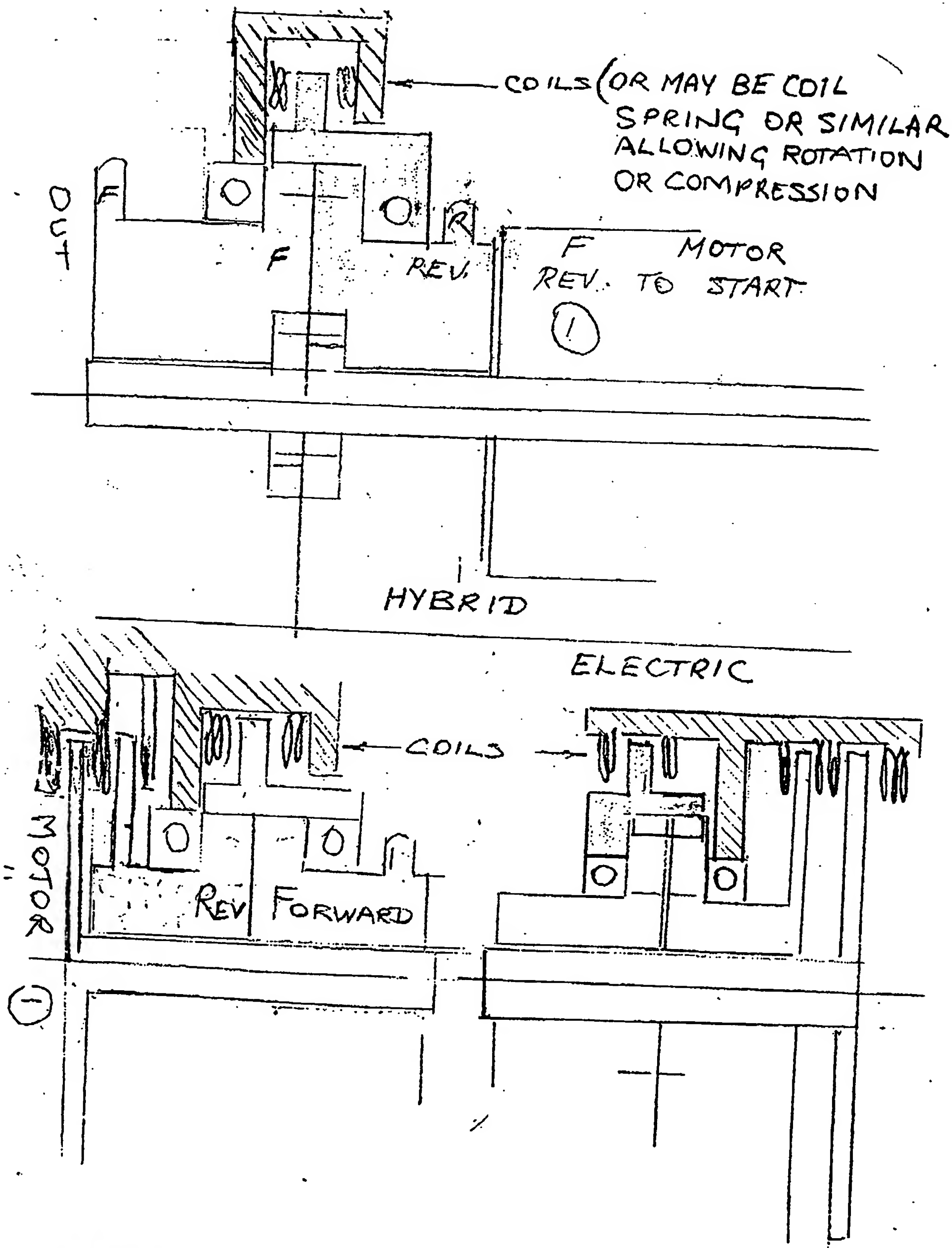

m2
Variable 1
Motor 2
|u|
Abs1
Backlash1
Gear
Dead Zone
Scope
gout
To Workspace
m1
Variable 2
Motor 1
Backlash
Gear Ratio
7
Constent

Fig 8


D
COILS (OR MAY BE COIL SPRING OR SIMILAR ALLOWING ROTATION OR COMPRESSION
OUT
F
F
R
REV.
F
REV. MOTOR TO START
1
HYBRID
ELECTRIC
COILS
MOTOR
REV
FORWARD

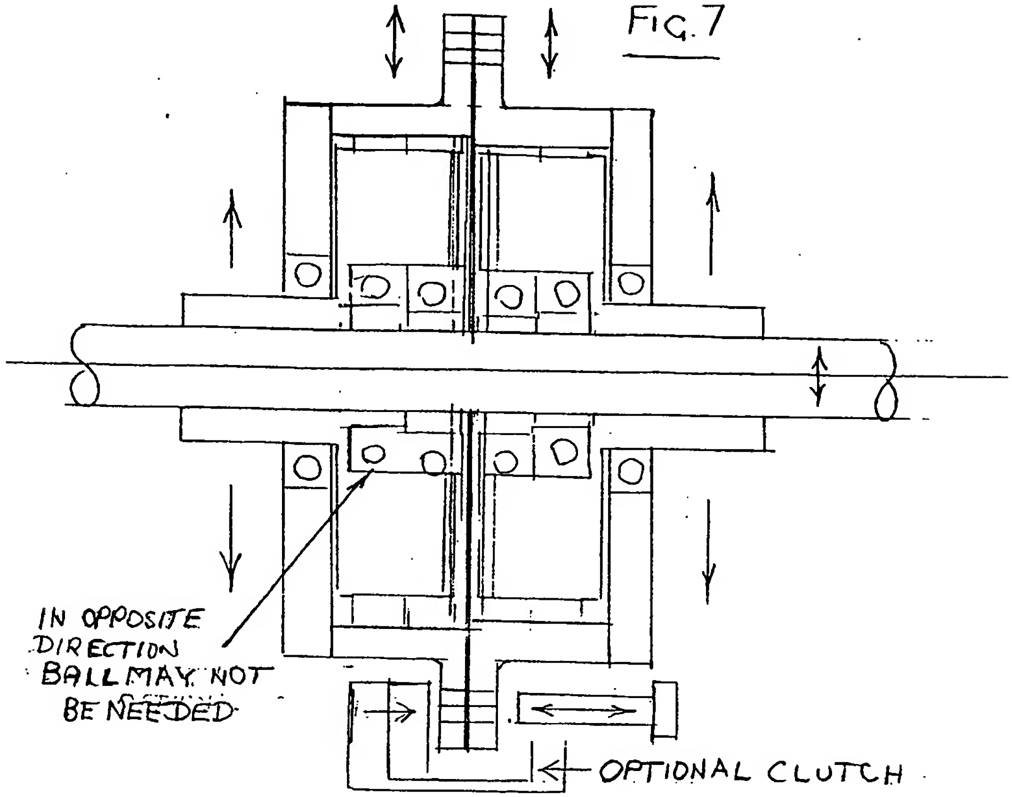
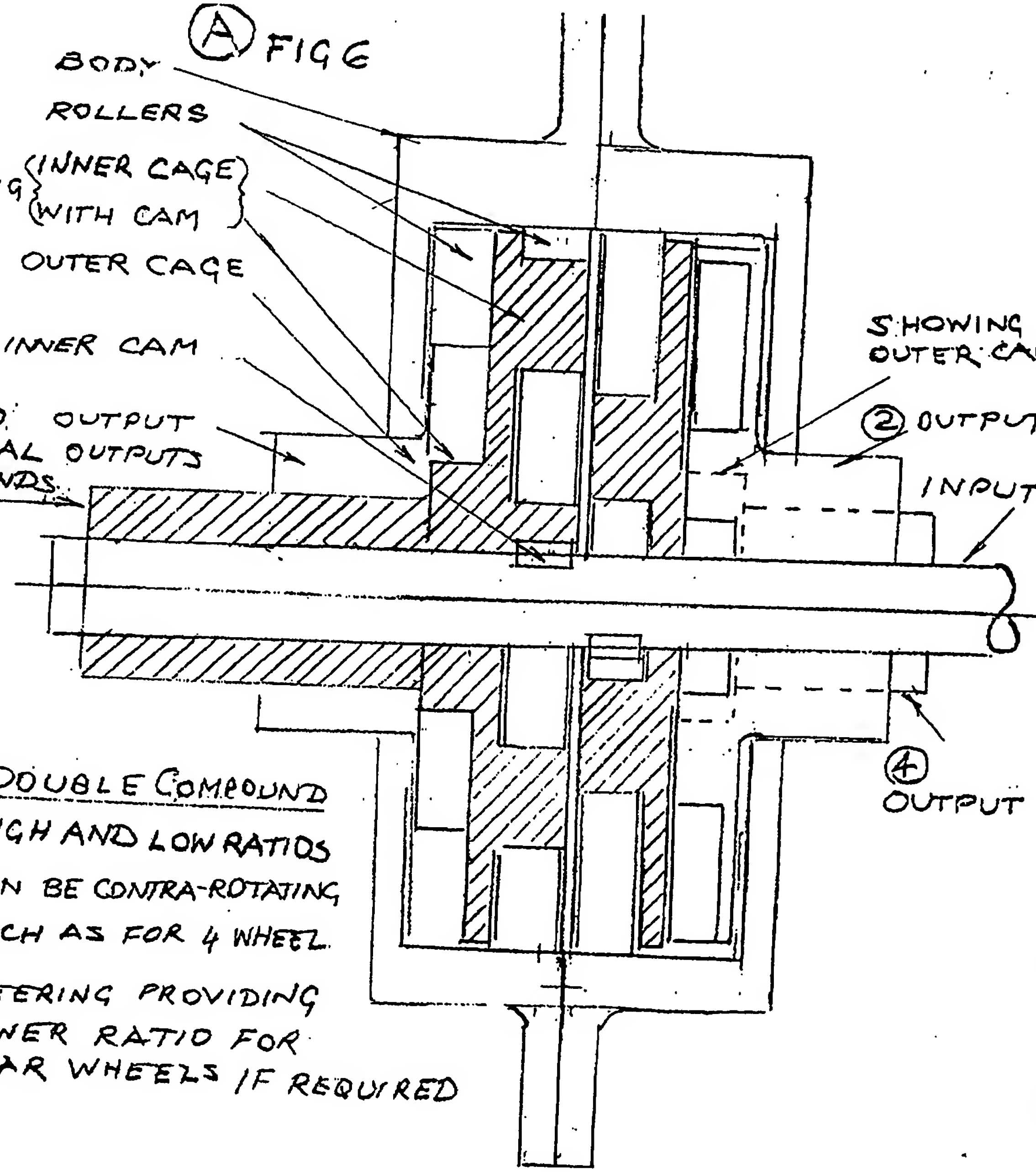

IN OPPOSITE
DIRECTION
BALL MAY NOT
BE ~~NEEDED~~
OPTIONAL CLUTCH

FIG. 7

ARTHURS PATENT '88
COVERS ROLLERS
AND DOUBLE ROW
OF CAMS + ROLLERS

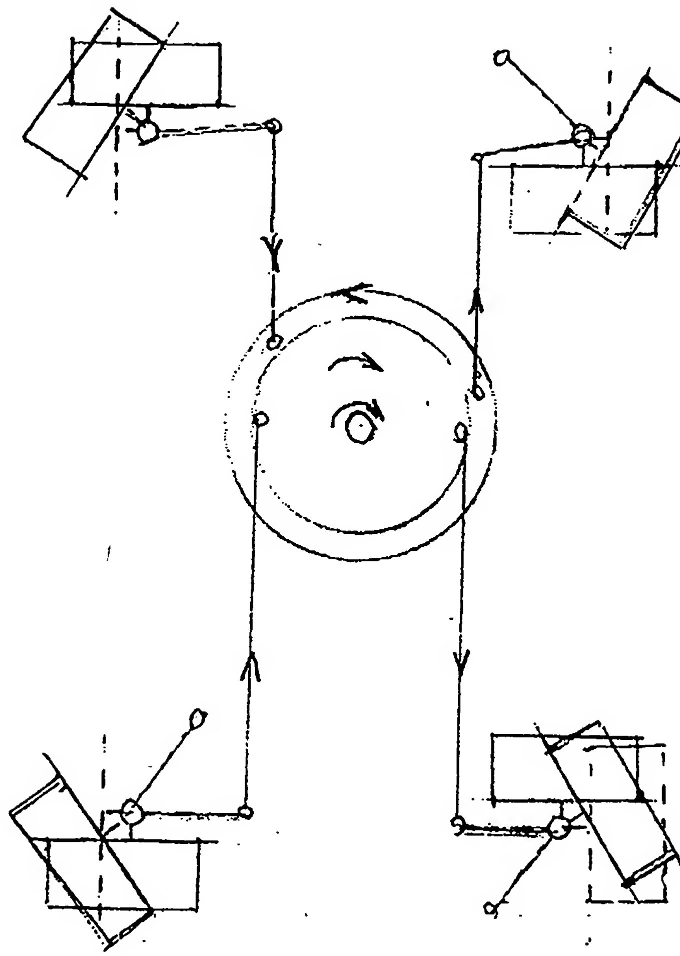
Ⓐ FIG 6



DOUBLE COMPOUND

HIGH AND LOW RATIOS
CAN BE CONTRA-ROTATING
SUCH AS FOR 4 WHEEL
STEERING PROVIDING
LOWER RATIO FOR
REAR WHEELS IF REQUIRED

FIG 5



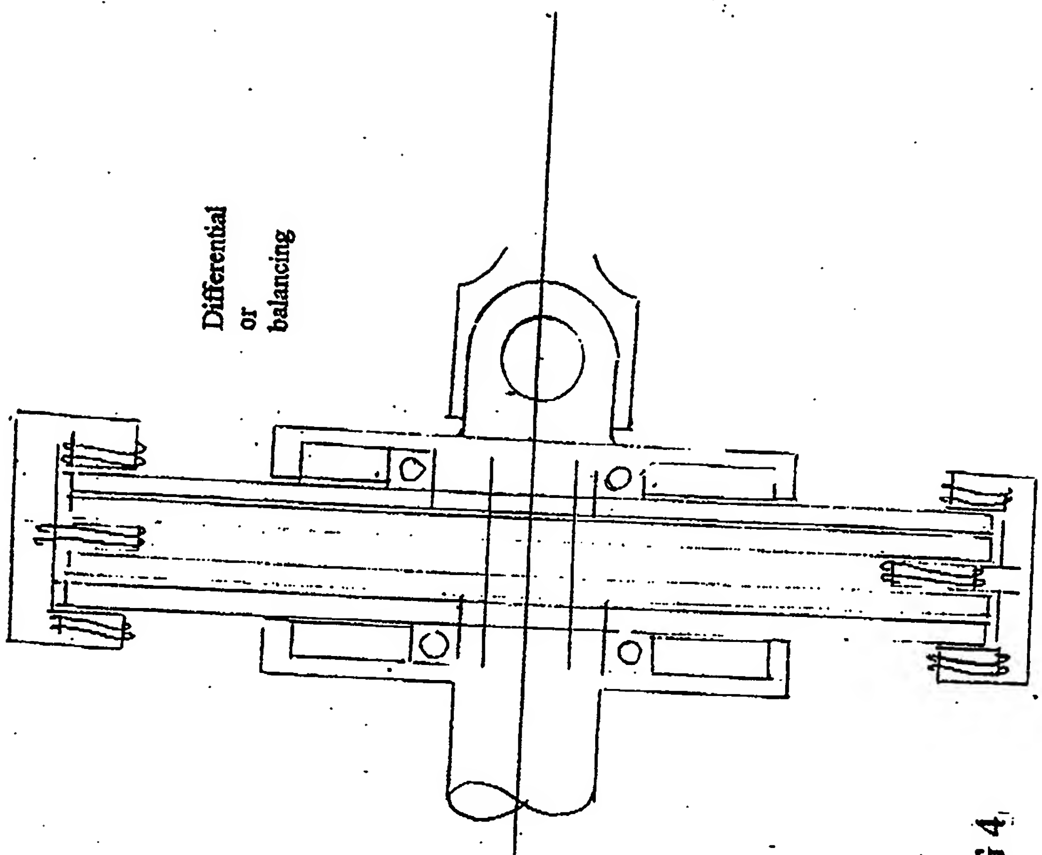
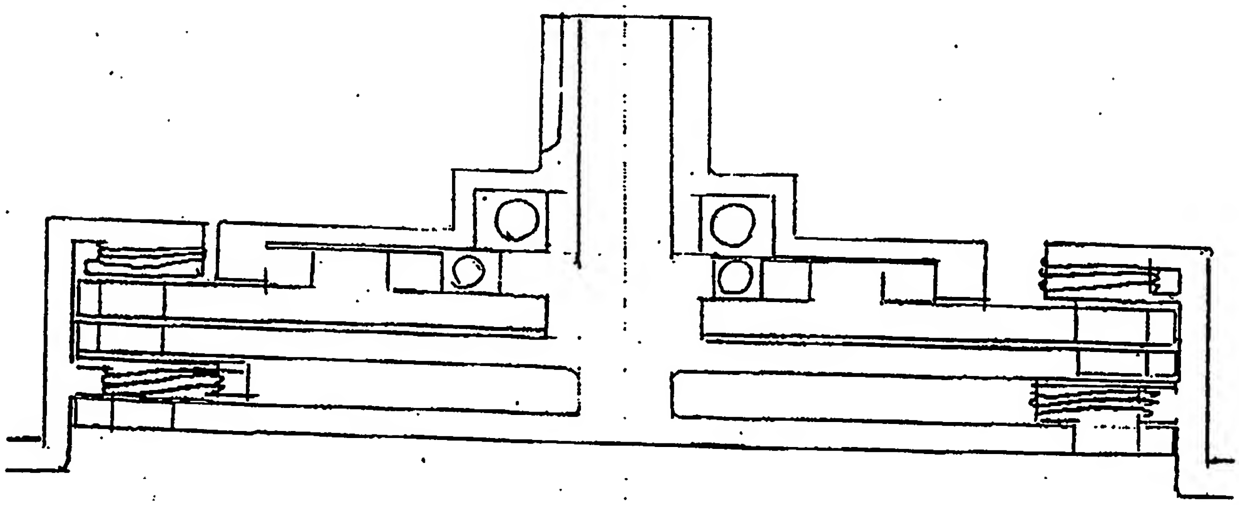
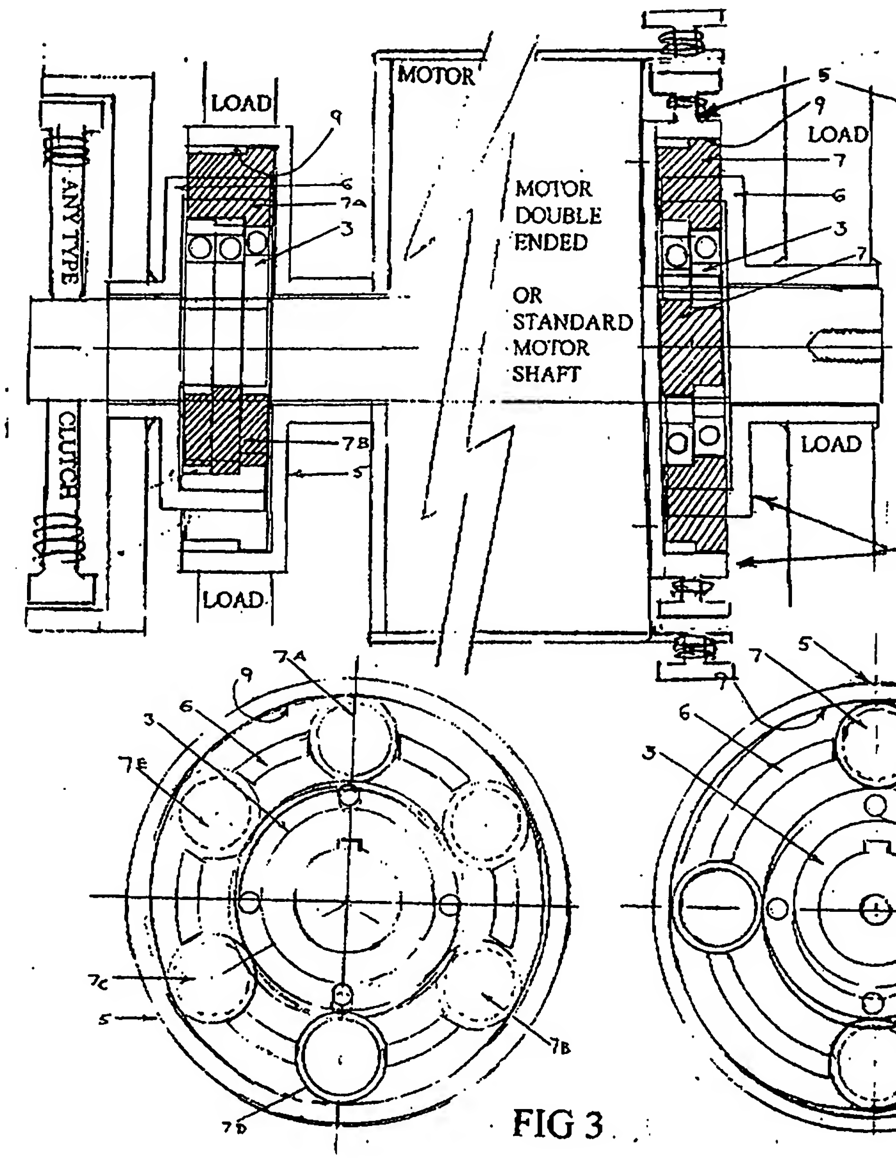


FIG 4



OPTIONALLY EITHER SIDE OR BOTH SIDES CAN BE VARIABLE SPEED OR FIXED SPEED RATIOS SHOWN HERE
2:1
3:1
1:1
-1 to +1



OPTIONALLY FIXED OR:-
1. GENERATOR
2. ACCELERATOR
3. ANY TYPE CLUTCH
4. FLUID CONTROL
5. BRAKE
6. BALANCING FOR OPTIONAL CONTRA-ROTATION OF

PARTS OF THE GEAR MAY BE INTEGRALLY MANUFACTURED WITH THE HUB OF WHEEL OR SAY, IMPELLOR BLADE

FIG 3

FIGS 1/1

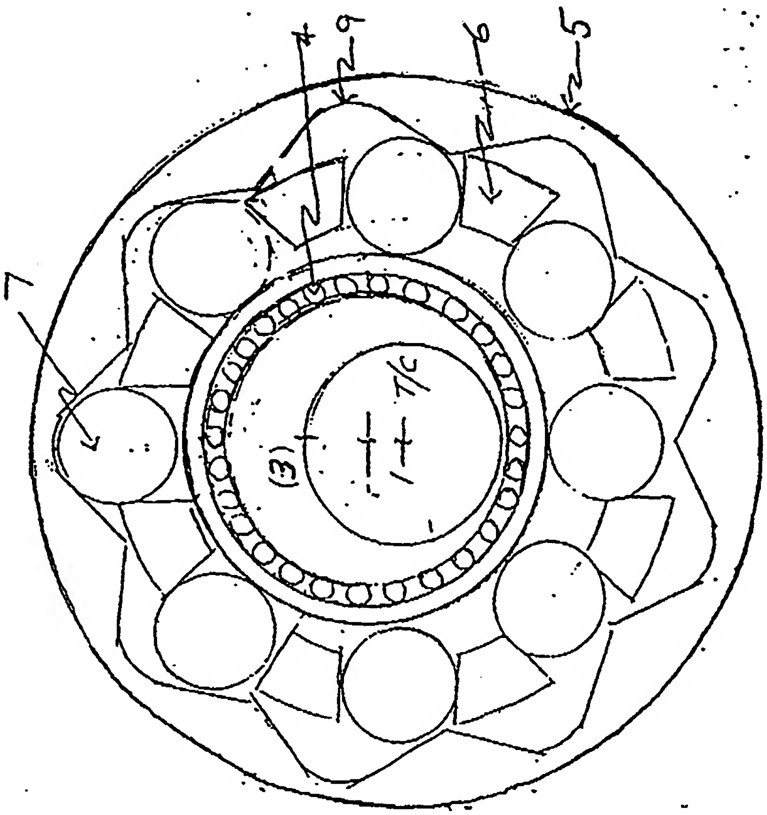


FIG 1.

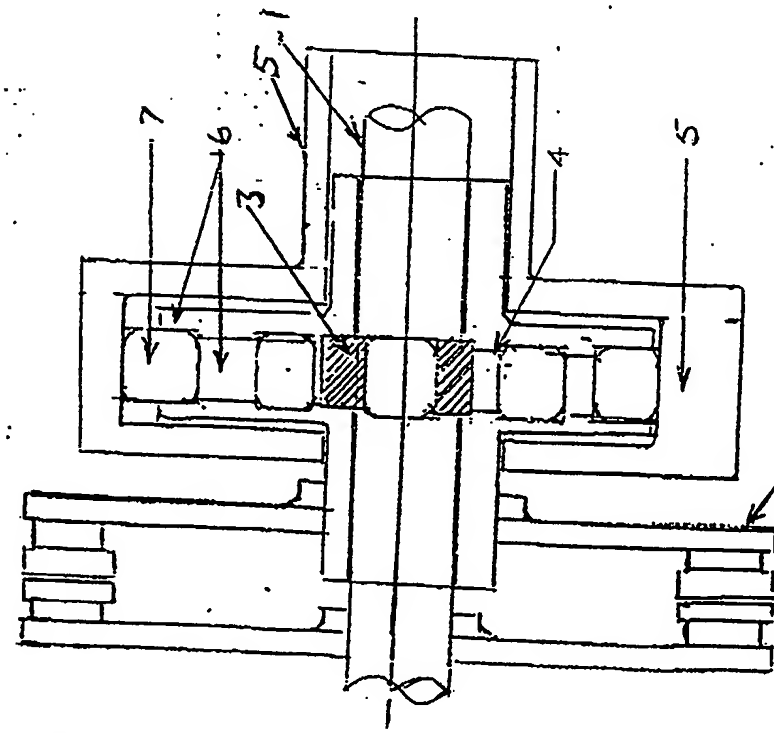


FIG 2

CLAIMS

Claim 1

A gear ratio including the following components:

(a) An outer body

(b) At least one cage

(c) A centre shaft

A first means between said centre shaft and said cage,

A second means between said cage and said outer body wherein upon rotation of said shaft, said cage, or said outer body at least one of the remaining said components (shaft, cage, or outer body) is caused to rotate and wherein variation of output of one component being either said shaft, said cage or said outer body is controlled between zero and a maximum value corresponding to variation of the ratio of the angular velocity of the two other components (said shaft, cage, or outer body)

CLAIM 2

A gear ratio set as described in Claim 1 including a variable brake and wherein said variable brake includes a variable load means supported between two of either said shaft, said cage and/or said outer body such that variation of a load between zero and a maximum value on one component corresponds to variation of the ratio of the angular velocity between the other components (said shaft, cage or outer body).

DATED THIS 16th DAY OF NOVEMBER 1998

MALCOLM LEONARD STEPHEN DEAN
By his Patent Attorneys
PIZZEYS

By arranging at least a second roller (FIG 3) cage in a 90 to 120 degree angle to the first roller cage, it therefore also requires at least a second cam to be at 120 to 180 degree to the first. Fitting rollers which will allow the compact movement has also been overcome by providing a step along their length so as to pass over the adjacent cam and thereby allowing for the option of a tension spring to control end play and also provide an optional wear reduction feature by tapering (for example) the outer body when machining the scallops.

The rollers also all move in the same direction as the surface they are in contact with.

It will be appreciated that modification and alterations can be made to the present invention as described above without departing from the inventive concept as defined in the following claims.

The present invention finds application in electric motors and electric motor design which can provide motors as shown in FIG 4 to be tested by simulation (FIG 9).

The present invention improves the action of magnetic clutches; improves regenerative feedback through application of the contra-rotational shaft with the outer body; integrates,sums and subtracts rotational forces; has the ability to produce and vary any required rotational force which results from integrating varying input rotational forces independently accelerated in a method suitable to optimise their design.

FANS A prior art Fan Company's publication claims contra-rotational exerts up to 2.5 to 3 times more pressure in a wind tunnel. In order to achieve the most relevant speed to the fan industry, it is necessary to start a load efficiently as near to a 2 to 1 ratio so as to have sufficient R.P.M. when using standard 50 cps motors. The present gear invention now makes this possible by at the same time also substantially reducing wing tip noise (FIGS 3, 4 and 7). It may be possible to contra-rotate propellers on the end of a motor using fluid flow to balancethem with our planned propeller designs.

The contra-rotation also has applications in the propulsion of any land or sea craft and aircraft. (FIG 3 4 and 7)
Previously, such action was considered too costly. However, because of the optional roller design of the present invention which provides a choice to use only one (or more of each) rotating discs to combine and contain, for example, a planetary cage, a motor rotor, or set of coils, an outer body for the next stage, a row of magnets, and, for example, a cam (star) for another stage, such that advanced features are more economically viable.

This invention also provides a device to provide or include a type of biasing, ramping up or fast acting rotational energy storage mechanism which allows optimum torque to be gained by any internal or external rotational force when stepping through discreet gear systems.

clutch. Also there is a power gain from a more efficient control of the electric motors in acceleration and braking. There is less heat generated inside this gear and so requires less cooling. All of those factors allow the gear to have a smaller size which then has more surface area per kg, thereby increasing the cooling effect per kg and thus reducing the weight of the cooling systems and the overall size requirement. Reduced size is reduced weight for the same power output.

Further discussion on certain prior art and the improvements thereto offered by the present invention will now be detailed.

Another advantage is a computer simulation programme for the CNC machining of scallops so that the fan rotation direction will change the normally symmetrical shape of the scallops to allow for directional and/or dynamic momentum wear. Another advantage of the present invention is the higher ratio provided, as illustrated by the multifunction cage in FIG 6 which has a cam integrated on its back for the next stage of rollers, the eight scallops by two sets of nine rollers giving a 81:1 ratio within the same body. If the same is duplicated with, for example, eight scallops and seven rollers, all on the same shaft, a lower ratio is provided. The compound contra-rotating action offered by the present invention should find use as FOUR WHEEL STEERING (FIG 5) for vehicles (ie, if the rear wheels require a lesser turning circle), or for power assisted steering or even to equally turn the wheels for a vehicle to go sideways or for angular parking or similar. The gear can be conveniently supported by the outer body. Of course, just a simple single reduction would be necessary if it is used as steering or equaliser for invalid mobiles, ride-on movers or similar smaller-type vehicles. If necessary, vehicles such as trucks may require different ratios for wheels to turn in the same direction. The four wheel steering or sideways motion, can be for any type of vehicle, and further the planetary drives can be remotely controlled together with auxiliary motors driving the wheels of trailers or similar.

It is possible to spin up the two (or more) motors at opposing high frequencies without the output drive moving, then control the frequency of motor (or motors). The resulting output from the heterodyning gear (which is mixing these two frequencies) will be to produce a low frequency, high torque force at the output drive shaft. A physically smaller gear has less weight.

There is one major limitation of 99% of all electric motors. Inherently electric coils have a small delay time from the moment when power is applied to when the magnetic force is delivered. This small time is constant (only dependent on temperature) but at a specific R.P.M. will equate to 1° of rotation. Therefore, maximum efficiency can only be attained at one R.P.M. All other R.P.M's are not as efficient. The microprocessor control possible with the present invention can move the pulse timing anywhere, and could easily track the most efficient angle relative to the current R.P.M. Microprocessor control increases the power efficiency resulting in less wasted power within the gear.

Since our microprocessor has total control of the switching times (phase angle) of each pole, (as per above) whilst regenerative braking the microprocessor can track the most efficient timing depending on the R.P.M. to produce the maximum power out of the gear and will stop the output drive as fast as possible. Auxiliary brakes can thus be downgraded, again reducing the overall weight of the product.

There is no need for a clutch within this unit thereby reducing weight and wasted power within the gear whilst interrupting the drive mechanism.

Since the gear is infinitely variable the output drive can be accelerated from stop to any speed smoothly.

Several aspects of this motor have improved the power efficiency of this motor-gearbox, thereby reducing the need for a large size. There is less power loss from not having frictional couplings of electrical parts or mechanical meshing of gears or

5. The present invention complements existing magnetic brake systems.
6. The present invention allows for the direct replacement of existing traction drives.
7. The present invention can be operated by electronic or manual control including handles, levers or push buttons.

Additional features of the present invention will now be described. These following pages, to page 24 line 6, describing optional manufacturing method of achieving the various choices of manufacturing some of the relevant designs, however there are many other variations such as described in this patent and the following drawings, Fig 1 to 18.

Electronic, Hydraulic or Molecular control offers design flexibility.

Either electric motors or hydraulic motors or a molecular coupling system could be used to control the gear ratio mechanism. The most efficient power to weight ratio could be attained if the machine already has a hydraulic system. Single or dual or more electric motors could be used to control, bias and drive the heterodyne gear. Internal or external magnetic controls could also be used to bias the gearing.

The motor may not have any active parts rotating. Only the magnets rotate offering the benefit of no rotating connections to cause power loss from the output drive through friction. There is no power losses from frictional couplings of electrical parts. There is also the option of having coils rotating.

Few moving parts results in lower drag, within the gear. Therefore, minimal power is lost to friction and heat. It is possible for only one part to rotate within each motor, however refer to the multi-rotor motors fixed to multi gear shafts for huge efficiencies. Within the gear there can be few moving parts, however the ability to integrate, contra-rotate and parrallel up motors is seen as extremely beneficial, especially if the entire motor may supported on a common shaft within the electric motor (Refer to Fig's 3 to 18 herein) with internal gear (EMIG), thereby reducing internal drag. Reducing drag internally reduces the heat generation within the EMIG. This allows the EMIG body to be manufactured from lighter materials (which usually do not have good heat transfer characteristics). Less mechanical parts meshing, results in less power loss within the gear.